In the United States Court of Federal Claims

No. 12-303C

(Filed Under Seal: January 27, 2017)

(Reissued: February 6, 2017)

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HITKANSUT LLC, et al.,	)	Post-trial decision in a patent case; 28 U.S.C. § 1498; infringement; patent-eligible subject matter; nonobviousness; enablement; reasonable and entire compensation
	)	
Plaintiffs,	)	
	)	
v.	)	
	)	
UNITED STATES,	)	
	)	
Defendant.	)	
	)	
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John S. Artz, Dickinson Wright, PLLC, Troy, Michigan, for plaintiffs. With him on the briefs and at trial were John A. Artz and Franklin M. Smith, Dickinson Wright, PLLC, Troy, Michigan.

Gary L. Hausken, Assistant Director, Commercial Litigation Branch, Civil Division, United States Department of Justice, Washington, D.C., for defendant. With him at trial and on the briefs was Joss Nichols, Attorney, Commercial Litigation Branch, Civil Division, United States Department of Justice, Washington, D.C. With him at trial were Benjamin Richards, Attorney, Commercial Litigation Branch, Civil Division, United States Department of Justice, Washington, D.C, and Emily Schneider and Nathaniel Sloan, Attorneys, United States Department of Energy, Washington, D.C. With him on the briefs were Benjamin C. Mizer, Principal Deputy Assistant Attorney General, Civil Division and John Fargo, Director, Commercial Litigation Branch, Civil Division, United States Department of Justice, Washington, D.C.

OPINION AND ORDER[1]

LETTOW, Judge.

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[1]Because this order might have contained confidential or proprietary information within the meaning of Rule 26(c)(1)(G) of the Rules of the Court of Federal Claims ("RCFC") and the protective order entered in this case, it was initially filed under seal. The parties were requested to review this order and to provide proposed redactions of any confidential or proprietary information. No redactions were requested.

This post-trial decision addresses plaintiffs' claim for damages attributable to alleged infringement of a patent for a method of processing materials, specifically including metal parts, to improve their properties. Plaintiffs, Hitkansut LLC and Acceledyne Technologies, Ltd. LLC (collectively, "Hitkansut"), allege that the United States, acting through Oak Ridge National Laboratory ("Oak Ridge" or "the government"), infringed their patent, United States Patent No. 7,175,722 ("the '722 patent"), entitled "Methods and Apparatus for Stress Relief Using Multiple Energy Sources."

Donna Walker is the inventor of the '722 patent, which describes a method for processing physical structures through the concurrent application of multiple energies. In November 2003, after filing a patent application, Ms. Walker met with researchers at Oak Ridge, a government-funded laboratory pursuing scientific research that encompasses metal processing among other fields. Ms. Walker signed a nondisclosure agreement with Oak Ridge, disclosed her invented method as described in her patent application, and demonstrated the invented method by applying induction heating and vibration concurrently to metals. Subsequently, Oak Ridge researchers received multiple patents for a materials processing method that used concurrent application of induction heating and a magnetic field, termed thermomagnetic processing ("TMP"), to treat metal parts. Hitkansut and Acceledyne, the owner and licensee of the '722 patent, respectively, allege that Oak Ridge's TMP method infringes Claims 1, 6, and 11 of the '722 patent, and request damages for the alleged infringement. The government responds that no infringement has occurred and also contends that the '722 patent is invalid due to patent-ineligible subject matter, obviousness, and lack of enablement. Further, the government argues that even if Oak Ridge did infringe the '722 patent, Hitkansut would only be entitled to a reasonable royalty of $200,000 and delay damages of $16,000.

A fourteen-day trial was held in Washington, D.C., commencing on May 23, 2016 and ending on June 22, 2016. Following post-trial briefing, closing arguments were heard on October 20, 2016. The case is now ready for disposition.

FACTS[2]

A. The '722 Patent

Donna Walker, the inventor of the '722 patent, *see* PX 58 (the '722 patent), is the majority owner of Hitkansut and Acceledyne, Tr. 32:18 to 33:12 (Test. of Donna Walker).[3] Hitkansut owns the patent and exclusively licenses it to Acceledyne. Tr. 33:15-21 (D. Walker). Ms. Walker first filed a provisional patent application on August 16, 2002. PX 476 (Provisional

[2]This recitation of facts constitutes the court's principal findings of fact in accord with RCFC 52(a). Other findings of fact and rulings on questions of mixed fact and law are set out in the analysis.

[3]Citations to the trial transcript are cited as "Tr. __." Citations to plaintiffs' exhibits are identified as "PX __," defendant's exhibits are denoted as "DX __," and joint exhibits are referred to as "JX __." Plaintiffs' demonstrative exhibits are cited as "PDX __."

Application); Tr. 47:7-10, 48:15-22 (D. Walker). Within the twelve-month period following the provisional application, on July 31, 2003, Ms. Walker filed her formal patent application, claiming priority to her provisional application and incorporating that application by reference. '722 patent, col. 1, lines 7-12; Tr. 47:11-15 (D. Walker).[4] The patent was issued on February 13, 2007.

The '722 patent describes a method of "changing physical properties of a structure using concurrent application of multiple energy types to the structure, and methodologies for determining operational settings for concurrent application of multiple energy sources to a structure." '722 patent, col. 2, lines 29-32. The '722 patent consists of fourteen claims, three of which are relevant to this dispute: Claims 1, 6, and 11.[5] Claim 1 is an independent claim on which Claim 6 depends, and Claim 11 is an independent claim without any dependent claims.

Claim 1, the first independent claim, specifies:

A method of changing a physical property of a structure, comprising:

[a] providing a first energy to a structure by performing a first energy process according to an operational setting, at least one of the operational setting and a time value being selected according to a first order rate relationship for the first energy process, according to a first order rate relationship for a second energy process, and according to a desired physical property value; and

[b] providing a second energy to the structure by performing the second energy process;

[c] wherein the first and second energy processes are performed concurrently for at least the time value;

[d] wherein the first order rate relationship for the first energy process relates application of the first energy to the structure and a physical property of the structure;

[4]Ms. Walker is a materials scientist who has a bachelor's degree in physics, mathematics, and political science from Northwestern University and a master's degree from the University of Oregon. Tr. 34:9 to 35:9 (D. Walker). She had also completed course work for a doctorate and finished a thesis on the microanalysis of electrified welds, but did not defend her thesis and never received a doctorate. Tr. 35:19 to 36:8 (D. Walker). Ms. Walker worked at Boeing for a number of years as a metallurgist, focusing particularly on the properties of aluminum alloys and stress relief of aluminum parts, sheets, and forgings. Tr. 36:13 to 37:17 (D. Walker).

[5]As discussed *infra*, Claims 2, 7, 8, and 14 were originally also at issue, but they have been ruled invalid in previous decisions in this case.

> [e] wherein the first order rate relationship for the second energy process relates application of the second energy to the structure and the physical property;
>
> [f] wherein the first and second energies are different;
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> [g] wherein the total energy provided to the structure by the first and second energy processes is above an activation energy for the material of the structure;
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> [h] wherein the first energy is thermal and wherein the second energy is oscillatory;
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> [i] wherein the operational setting is a temperature setting, wherein one of the temperature setting and the time value is selected according to the first order rate relationship for the first energy process, according to the first order rate relationship for the second energy process, according to the desired physical property value, and according to the other one of the temperature setting and the time value; and
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> [j] wherein the first order rate relationship for the first energy process is a first Larson[-]Miller relationship that relates application of thermal energy to the structure and the physical property, and wherein the first order rate relationship for the second energy process is a second Larson[-]Miller relationship that relates application of oscillatory energy to the structure and the physical property.

'722 patent, col. 19, line 43 to col. 20, line 16 (adding bracketed designations for the ten separate elements of Claim 1).[6]

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[6]The terms of Claim 1 and the other claims in the patent reflect to a significant extent the usage of persons who work in metallurgy and materials engineering. In that vein, the court construed the term "first order rate relationship" to mean

> a mathematical relationship between the application of an energy to a structure and the responsive change in the structure that varies with the value of one variable, and where the rate of change in the variable is exponential such that a plot of the natural logarithm over time results in a straight line.

Hitkansut LLC v. United States, 114 Fed. Cl. 410, 419 (2013) ("*Hitkansut II*"). Correlatively, "Larson-Miller relationship" was construed to mean "a parametric representation of a system of physical properties of a structure subjected to energy processes, which can take the form of the equation $P = {}^{\Delta H}/_{R} = T\,(C + \log t)$." *Id*. at 426.

Claim 6, which is dependent upon Claim 1, provides:

> The method of claim 1, wherein the physical property is internal stress, and wherein the desired physical property value is one of a remaining internal stress value and an internal stress reduction value.

'722 patent, col. 20, lines 50-53.

Claim 11, the second relevant independent claim, describes:

> A method of changing a physical property of a structure, comprising:
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> [a] providing a first energy to a structure by performing a first energy process according to an operational setting;
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> [b] providing a second energy to the structure by performing a second energy process;
>
> [c] wherein the first and second energy processes are performed concurrently to provide energy above an activation energy for the material of the structure for at least a time value;
>
> [d] wherein one of the operational setting and the time value are selected according to a desired physical property value and according to a first order rate relationship that relates concurrent application of the first and second energy to the structure and the physical property of the structure; and
>
> [e] further comprising determining the Larson[-]Miller relationship that relates concurrent application of the first and second energy to the structure and the physical property of the structure.

As the court commented in its claim construction decision,

> The term "Larson-Miller relationship" stems from a seminal technical article by two researchers, Messrs. Larson and Miller, which article was cited in the '722 patent as prior art. *See* '722 patent at 2 (citing F. R. Larson and James Miller, A *Time-Temperature Relationship for Rupture and Creep Stresses*, Transactions of ASME, pp. 765-775 (July 1952) ("Larson & Miller, *Rupture & Creep Stresses*")). Larson and Miller were employed by General Electric Company and performed research on a number of metallic alloys for the purpose of addressing turbine blade life. *See* Larson & Miller, *Rupture & Creep Stresses*, at 765.

Hitkansut II, 114 Fed. Cl. at 419 n.8.

'722 patent, col. 21, lines 47-66 (adding bracketed designations for the five separate elements of Claim 11).

The patent specification states that the concurrent application of multiple energies "significantly reduce[s] the time and/or energy required to change a physical property of interest, such as reducing remaining internal stress in manufactured parts or other structures, compared to previous techniques." '722 patent, col. 2, lines 35-37.[7] For example, the concurrent application of thermal and oscillatory energies can be used to achieve stress relief in aluminum samples. *See* '722 patent, col. 17, line 52 to col. 18, line 26; *see also* '722 patent, col. 16, lines 22-24 (explaining that "separate application of heat at this temperature or of vibration alone for this time would not yield the desired stress-relief goal"). In describing a first order rate relationship that relates concurrent application of at least two different energy processes, the specification provides:

> [T]he first L[arson]-M[iller ("L-M")] parameter may be determined according [to] a first L-M relationship (*e.g.*, L-M curve, etc.), wherein a desired remaining internal stress value is selected along the Y axis of the first L-M curve, and the corresponding parameter ("*P*") value is ascertained along the X axis (P_1). A second L-M parameter is determined for the desired physical property value according to a second L-M relationship (*e.g.*, a second L-M curve) by locating the desired internal stress value on the Y axis of the second L-M curve, and locating the corresponding second parameter value (*e.g*, P_2) along the X axis. *A third L-M parameter* (*e.g.*, P_3) *may optionally be determined* according to the first and second L-M parameters (P_1 and P_2), such as by subtraction (*e.g.*, $P_3 = P_1\text{-}P_2$). An operational setting and a time value are then selected according to [P_3]. . . .

'722 patent, col. 3, lines 22-36 (emphasis added).

B. Oak Ridge

Oak Ridge is a national laboratory located in Oak Ridge, Tennessee. Tr. 690:19-25 (Test. of Roger Allen Kisner, Distinguished Research and Development Staff Member at Oak Ridge). It receives approximately 80 percent of its funding from the United States Department of Energy. Tr. 537:4-7 (Test. of Jamie Dean Standridge, Director of Planning and Budget for the Office of Science, United States Department of Energy, Oak Ridge Office). The Office of Science, which is within the Department of Energy, is responsible for oversight of the laboratory. Tr. 521:4-15 (Standridge). Oak Ridge is managed by UT-Battelle, a not-for-profit organization associated with the University of Tennessee and the Battelle Memorial Institute. Tr. 582:7-20 (Standridge). The stated mission of the Oak Ridge laboratory is

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[7]The court uses the specification in the '722 patent to assist in understanding the language of the claims themselves, but not to ascribe limitations on the claims that are not present in the claim text. *See Hill-Rom Servs., Inc. v. Stryker Corp.*, 755 F.3d 1367, 1371 (Fed. Cir. 2014) ("While [the court] read[s] claims in view of the specification, of which they are a part, [the court] do[es] not read limitations from the embodiments in the specification into the claims.") (citing *Liebel-Flarsheim Co. v. Medrad, Inc.*, 358 F.3d 898, 904 (Fed. Cir. 2004)).

> to deliver scientific discoveries and technical breakthroughs that will accelerate the development and deployment of solutions in clean energy and global security, and in doing so, create economic opportunity for the nation.

PX 6 (United States Department of Energy's Ten-Year Plans for the Office of Science National Laboratories (July 2013)) at 128; Tr. 542:24 to 543:4 (Standridge).

1. Ms. Walker's disclosure of her method to Oak Ridge, beginning in November 2003.

Ms. Walker first contacted Oak Ridge in 2003. Tr. 87:11-13 (D. Walker). On November 11, 2003, Ms. Walker, acting through Acceledyne, signed a non-disclosure agreement with Oak Ridge, acting through UT-Battelle. PX 85 (Non-Disclosure Agreement). The agreement was effective as of October 30, 2003, and expired three years from the effective date. *Id.* at 1. After signing the agreement, Ms. Walker sent her '722 patent application, which was pending at that time, to Dr. Ray Johnson, the then-manager of the research and development program at Oak Ridge. Tr. 89:23-25 (D. Walker); Tr. 424:11-20 (Test. of Dr. Ray Johnson, Manager of Research and Development at Oak Ridge). Ms. Walker then conferred by telephone with Dr. Johnson and two other Oak Ridge researchers, Dr. Paul Becker and Dr. Gerard Ludtka, on November 24, 2003, to discuss her invention. PX 84 (Contact Log, signed by Ms. Walker's son, Michael Walker (Nov. 24, 2003)); *see also* Tr. 91:3-22 (D. Walker); 324:25 to 325:17 (Test. of Michael Walker); 1583:24 to 1584:9 (Test. of Dr. Gerard Ludtka, Distinguished Research Staff Member at Oak Ridge). At the time of the call, the United States Patent and Trademark Office ("PTO") had not yet issued the '722 patent or published the patent application. Tr. 93:19 to 94:6 (D. Walker). Shortly thereafter, Dr. Ludtka wrote in an e-mail dated December 4, 2003:

> [Ms. Walker] uses a combination of a thermal method and some other method which usually is vibratory type to do residual stress relief on aluminum alloys (and other material systems). She also has demonstrated accelerated aging kinetics on aluminum alloys. So *her method has the potential for a lot of energy savings by being able to do things at significantly shorter times (seconds to minutes compared with hours) and sometimes at lower temperatures than conventionally required using just thermal (heat treatment) methods alone*.

PX 180 (E-mail from Dr. Gerard Ludtka to Dr. Gail Mackiewicz-Ludtka (Dec. 4, 2003, 3:34 PM)) (emphasis added); *see also* Tr. 1581:12-23 (Ludkta).

Oak Ridge's research and development program provided Ms. Walker with a subcontract, which included a budget of $35,000 and an opportunity to prove her concept. Tr. 94:12-25 (D. Walker); Tr. 424:19 to 425:8 (Johnson). Ms. Walker successfully presented the invented method described in the '722 patent, also referred to as "the Walker Process," by applying vibration and induction heating concurrently to metals and then presenting the samples to Oak Ridge. Tr. 97:11 to 98:2 (D. Walker); Tr. 425:3-15 (Johnson). Dr. Johnson and Dr. Becker later traveled to Michigan to observe Ms. Walker demonstrate her invention, prompting Dr. Johnson to describe Ms. Walker's project as "very successful, both in demonstrating substantial energy savings

resulting from the process and also in developing a body of technical and scientific data that provides an understanding of how the process works." PX 136 (Letter from Dr. Ray Johnson to Dr. Dale A. Gerard, Senior Manager, Materials Engineering, General Motors (Nov. 29, 2006)). Ms. Walker attempted to receive additional contracts or funding from Oak Ridge, but she was not successful. Tr. 105:25 to 106:4 (D. Walker)

2. Oak Ridge's research prior to Ms. Walker's 2003 disclosure.

In approximately 1999, Dr. Gerard Ludtka and several other Oak Ridge researchers began studying the processing of materials in a magnetic field. Tr. 698:12-15 (Kisner); Tr. 1895:12-18 (Ludtka). As a result of this research, Dr. Ludtka filed a patent application on August 13, 2002, which issued on August 10, 2004 as United States Patent No. 6,773,513 ("the '513 patent"), entitled "Method for Residual Stress Relief and Retained Austenite Destabilization." PX 91 (the '513 patent); Tr. 1585:6-24 (Ludtka). The '513 patent describes a method for affecting "residual stress relief or phase transformations in a metallic material" through the use of a magnetic field. '513 patent, Abstract. Specifically, the abstract of the '513 patent provides:

> In a first aspect of the method, residual stress relief of a material is achieved at ambient temperatures by placing the material in a magnetic field. In a second aspect of the method, retained austenite stabilization is reversed in a ferrous alloy by applying a magnetic field to the alloy at ambient temperatures.

'513 patent, Abstract.

Additionally, Dr. Ludtka and his Oak Ridge colleagues prepared a presentation of their magnetic field processing research on August 21, 2003, which included a stated goal of "[d]emonstrat[ing] and understand[ing] the influence of ultrahigh magnetic field processing on the phase equilibria and kinetics for three distinct ferromagnetic materials." PX 506 (Gerard Ludtka, et al., *Enhanced Performance and Energy Savings Through Ultrahigh Magnetic Field Processing of Ferromagnetic Materials (proposal D02/030)* (Aug. 21, 2003)) at ORL013-13076 to -77. The presentation explained that Oak Ridge's research involved subjecting particular materials to elevated temperatures, and then conducting "elevated temperature magnetic processing experiments under isothermal and continuous cooling conditions." *Id.* at ORL013-13082. Graphs illustrated the speed at which phase transformation occurred during magnetic field processing as the metal cooled, with temperature as the Y axis and time as the X axis. *See id.* at ORL013-13086 to -90.

3. Oak Ridge's TMP research after Ms. Walker's 2003 disclosure.

In March 2004, Dr. Ludtka and his research team at Oak Ridge submitted an invention disclosure for a method of treating metals through the *concurrent* application of two energies, induction heating and a high magnetic field. PX 175 (John Wilgen, et al., *Method for Non-Contact Ultrasonic Treatment of Metals in a High-Magnetic Field* (Mar. 18, 2004)); Tr. 1589:23 to 1590:5 (Ludtka). The concurrent application of induction heating and a high magnetic field to metals is central to Oak Ridge's TMP method. Tr. 1600:14-21 (Ludkta). The 2004 invention

disclosure contemplates that the method can "potentially be utilize[d] to minimize residual stress, accelerate phase transformation processes . . . and *enhance processes that have a threshold activation energy*." PX 175 at ORL019-14188 (emphasis added). The disclosure further explains:

> When induction heating is applied in a high magnetic field environment, it is possible to configure the induction heating coil in such a manner that high intensity ultrasonic treatment occurs inherently. The resulting configuration is that of a highly effective electromagnetic acoustical transducer (EMAT). . . . As a consequence, the synergistic combination of induction heating in a high-field magnet is a very effective method of creating a very high intensity acoustic environment. This provides a non-contact method for applying high-intensity ultrasonic energy to the processing of metals. . . .
>
> If the axis of the induction heating coil is aligned with the static magnetic field of a high field magnet, the heating current induced in the process metal surface interact[s] with the static magnetic field. *The result is a large oscillatory electromagnetic force, or pressure, that acts directly on the metal surface, at the induction heating frequency. The resulting acoustic pressure acts alternately to compress and expand (tensile stress) the sample*. The acoustic pressure can be quite substantial since the induced current is high and the magnetic field is high, resulting in a highly efficient EMAT.

Id. at ORL019-14189 (emphasis added); *see also* Tr. 726:21 to 727:3 (Kisner) (explaining that the combination of the induction heating and magnetic field creates the oscillatory force that acts on the metal part or sample).[8] Applying the induction heating in conjunction with the magnetic field created a force "so great" that it produced unexpected results on the processed metals. Tr. 729:6-14 (Kisner).

In November 2004, Dr. Ludtka and his team submitted a further invention disclosure, describing a method "for heating and cooling of work pieces in an ultrahigh magnetic field." PX 68 (Roger Kisner, et al., *Induction Heating and Rapid Quenching of Material in a High Magnetic Field Environment* (Nov. 22, 2004)) at ORL101-004824. This disclosure led to the filing of a patent application by Drs. Kisner, Wilgen, Ludtka, Mackiewicz-Ludtka, and Jaramillo, all of whom are researchers at Oak Ridge, on April 19, 2005. The patent issued on January 9, 2007 as United States Patent No. 7,161,124, entitled "Thermal and High Magnetic Field Treatment of Materials and Associated Apparatus." PX 69 (the '124 patent); Tr. 515:9-15 (Test. of Dr. John B. Wilgen, Research Staff Member at Oak Ridge). Claim 1 of the '124 patent describes an "apparatus for altering characteristics of a workpiece," with the apparatus comprising, among other things, a "means for thermally treating the workpiece in conjunction

[8]The oscillatory force is alternatively referred to as the Lorentz force, electromagnetic acoustical transducer ("EMAT"), or "J x B" force. *See* Tr. 726:25 to 727:3 (Kisner); PX 175 at ORL019-14189 to -90; DX 40 (Gerard Ludtka, *Magnetic Field Processing – A Heat Free Heat Treating Method* (Aug. 8, 2012)) at 40.22.23; Post-Trial Br. of the United States ("Def.'s Post-Trial Br.") at 14, ECF No. 225.

with the generated magnetic field so that the characteristics of the workpiece are [a]ffected by both the generated magnetic field and the thermal treatment." '124 patent, col. 11, lines 19-29. The '124 patent notes that the "heating and/or cooling of the workpiece can be carried out before, during, or after the exposure of the workpiece to the magnetic field." '124 patent, col. 2, lines 12-14.

On March 30, 2006, Dr. Ludtka and his team filed another patent application related to metal processing through the application of induction heating and a magnetic field, and this further patent issued on May 19, 2009 as United States Patent No. 7,534,980, entitled "High Magnetic Field Ohmically Decoupled Non-Contact Technology." PX 62 (the '980 patent). The '980 patent specification states that "when induction heating is applied in a high magnetic field environment, and the static magnetic field is aligned with the axis of the induction heating coil, then the electromagnetic force . . . is greatly enhanced." '980 patent, col. 5, lines 22-26. The specification further explains that "the amplitude of the acoustic pressure generated by induction heating within the high-field magnetic is at least 1000 times greater than the pressure generated by the intrinsic self-field of the induction heating by itself." '980 patent, col. 6, lines 11-14. Still further, Dr. Ludtka and his team at Oak Ridge filed a patent describing a method of metal processing via induction heating and a magnetic field on July 3, 2006, which issued on June 29, 2010 as United States Patent No. 7,745,765, entitled "Thermal and High Magnetic Field Treatment of Materials and Associated Apparatus." PX 139 (the '765 patent). Claim 1 of the '765 patent describes:

> A process for altering characteristics of a workpiece which includes an electrically-conductive material, the process comprising the steps of:
>
> > providing a workpiece comprising an electrically[-]conductive material within a bore of a magnet;
> >
> > providing, between the workpiece and the magnet, a means for thermally treating the workpiece;
> >
> > exposing the workpiece to an ultrahigh magnetic field of at least one Tesla generated by the magnet; and
> >
> > thermally treating the workpiece by the means in conjunction with the exposure of the workpiece to the magnetic field so that the characteristics of the workpiece are affected by both the ultrahigh magnetic field and the thermal treatment.

'765 patent, col. 11, lines 2-15.

In addition to obtaining these patents, Dr. Ludtka and his Oak Ridge colleagues have prepared various research reports, received funding, authored multiple publications, and received awards for their TMP-related research. *See, e.g.*, PX 163 (Gerard Ludtka, et al, *Use of High Magnetic Fields to Improve Material Properties for Hydraulics, Automotive, and Truck Components* (June 27, 2010)); PX 45 (2009 R&D 100 Award Entry Form); Tr. 1599:14-17,

1763:9-20 (Ludtka). Oak Ridge continues to study and research the TMP method to this day. Tr. 739:21 to 740:2 (Kisner).

Recently, Dr. Ludtka was listed as one of the inventors on a World Intellectual Property Organization ("WIPO") publication based on a Patent Cooperation Treaty ("PCT") application, published March 31, 2016, WIPO number 2016/046637 A1, entitled "Method for Producing A Structural Component Including A Thermomagnetic Tempering Process Yielding Localized Soft Zones." PX 510 (the WIPO Publication). The publication relates to a patent application filed on September 18, 2015, with a claimed priority date of September 22, 2014. PX 510 at 1. The invention is summarized, in pertinent part, as follows:

> The invention provides a method of manufacturing a structural component, such as a component for an automotive vehicle, with an improved tempering process. The method includes providing a workpiece formed of steel material; heating and forming the workpiece; quenching the formed workpiece; and tempering at least one portion of the quenched workpiece. The tempering step includes simultaneously applying thermal energy and a magnetic field to the workpiece. This thermomagnetic tempering process is more efficient than other tempering processes, and thus reduces costs associated with manufacturing the structural component.

PX 510 at 2; *see also* PX 510 at 14 (Claim 1).[9] The application explains that "both time and temperature are important variables used to achieve the desired microstructure, strength, and ductility during the tempering process. The following tempering parameter is often used to describe the interaction between time and temperature: $T\,(20 + \log t) \times 10^{-3}$ where T is temperature in Kelvin and t is time in hours." PX 510 at 8.

PROCEDURAL HISTORY

Hitkansut filed suit in this court on May 10, 2012, alleging that the government, through Oak Ridge, infringed the '722 patent and seeking compensation for the allegedly infringing use. *See generally* Compl. Discovery disputes arose prior to claim construction. In January 2013, Hitkansut filed a motion to compel the production of information "related to or derived from cooperative research and development agreements ('CRADAs') to which the government is a party," which this court granted in part and denied in part. *Hitkansut LLC v. United States*, 111 Fed. Cl. 228, 231, 239 (2013) ("*Hitkansut I*").[10] As issued, the '722 patent set out fourteen claims, seven of which were originally relevant to this dispute. *See Hitkansut II*, 114 Fed. Cl. at

[9]After a material's temperature is sufficiently elevated from heating in the induction field, "quenching" relates to the rate at which the material is cooled; the quenching process "can have an effect on the crystalline structure of the material." Tr. 714:21 to 715:4 (Kisner).

[10]Pursuant to court order, the parties filed a stipulated protective order on June 13, 2013. ECF No. 36. Subsequently, in October 2014, the court addressed pre-trial discovery disputes related to CRADA documents and classified Oak Ridge research information and projects. *Hitkansut LLC v. United States*, 119 Fed. Cl. 40, 42-43 (2014) ("*Hitkansut IV*"). Residual aspects of those disputes carried over to trial.

413. The parties submitted briefs on claim construction and presented oral arguments at a *Markman* hearing held on May 2, 2013. The court then issued its construction of twenty-one pertinent claim terms on July 25, 2013. *Id.* at 416-28.

Thereafter, the government moved for summary judgment, arguing that the claims in the '722 patent sought to patent subject matter that was ineligible, *i.e.*, not within the ambit of 35 U.S.C. § 101, and that the patent was thus invalid. *Hitkansut LLC v. United States*, 115 Fed. Cl. 719, 722 (2014) ("*Hitkansut III*"). Hitkansut filed a cross-motion requesting a declaration from the court that the claims in the '722 patent be deemed "eligible for patent protection." *Id.* This court granted the government's motion in part and denied it part, specifically granting the government's motion with respect to independent Claims 7 and 14 and dependent Claim 8, but not regarding independent Claims 1 and 11 or dependent Claims 2 and 6. *Id.* at 734. This court denied Hitkansut's cross-motion and withheld summary judgment on Claims 1, 2, 6, and 11 because other issues apart from subject-matter eligibility had arisen respecting those claims. *Id.* at 734 n.17.

After further factual development of the case, the government moved for summary judgment a second time with respect to the four remaining relevant claims, arguing that those claims failed the enablement requirement, thus rendering the patent invalid, because they contained substantial errors, or, apart from the errors, required undue experimentation. *Hitkansut LLC v. United States*, 119 Fed. Cl. 258, 263, 265 (2014) ("*Hitkansut V*"). The government also argued that Claim 2, a dependent claim, should be dismissed under 35 U.S.C. § 112 because it did "not specify a further limitation of the subject matter disclosed in Claim 1, the independent claim upon which it depends." *Id.* at 267. The court denied the government's motion with respect to Claims 1, 6, and 11, but granted the government's motion with respect to Claim 2 because that claim was invalid under 35 U.S.C. § 112, Paragraph 4 (2006). *Id.* at 268 (citing *Pfizer, Inc. v. Ranbaxy Labs. Ltd.*, 457 F.3d 1284, 1291-92 (Fed. Cir. 2006)).[11] As a result, Claims 1, 6, and 11 are the three claims in the '722 patent that remain relevant to this dispute.

After the parties completed discovery, a fourteen-day trial began on May 23, 2016.[12] Following post-trial briefing and closing argument, the case is ready for disposition.

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[11] Section 112 of the patent laws was amended by Subsection 4(c) of the Leahy-Smith America Invents Act ("AIA"), Pub. L. No. 112-29, 125 Stat. 284, 296 (2011). Subsection 4(e) of the AIA makes the change to Section 112 applicable to any patent application filed on or after September 16, 2012. Because the provisional and utility patent applications for the '725 patent were filed in 2002 and 2003 respectively, well before the application date of the AIA, the court looked to the pre-AIA version of Section 112 as the legal basis for its decision. *See Hitkansut IV*, 119 Fed. Cl. at 262 n.3; *see also*, *e.g.*, *Alcon Research Ltd. v. Barr Labs., Inc.*, 745 F.3d 1180, 1183 n.1 (Fed. Cir. 2014); *SD3, LLC v. Dudas*, 952 F. Supp. 2d 97, 103 nn.4-5 (D.D.C. 2013).

[12] Before trial began, Hitkansut filed six motions *in limine* and the government filed one motion *in limine*; all but one of these motions sought to exclude evidence from trial. This court denied the parties' motions, "with the exception of plaintiffs' motion to admit deposition testimony, . . . which [was granted] subject to preservation of specific objections to be heard at trial." *Hitkansut LLC v. United States*, 127 Fed. Cl. 101, 115 (2016) ("*Hitkansut VI*").

STANDARDS FOR DECISION

A. Patent Infringement Under 28 U.S.C. § 1498

Pursuant to 28 U.S.C. § 1498(a), the United States has waived sovereign immunity and vested in this court exclusive jurisdiction to adjudicate patent infringement claims against the federal government "[w]henever an invention described in and covered by a patent of the United States is used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same." 28 U.S.C. § 1498(a). Section 1498 provides in relevant part that "the use or manufacture of an invention described in and covered by a patent of the United States by a contractor, a subcontractor, or any person, firm, or corporation for the [g]overnment and with the authorization or consent of the [g]overnment, shall be construed as use or manufacture for the United States." 28 U.S.C. § 1498(a).

The government's unauthorized "use or manufacture" under Subsection 1498(a) is analogous to a taking of property under the Fifth Amendment of the United States. *See Motorola, Inc. v. United States*, 729 F.2d 765, 768 (Fed. Cir. 1984); *see also Hughes Aircraft Co. v. United States*, 29 Fed. Cl. 197, 208 (1993). The government "takes" a non-exclusive and compulsory license to a United States patent "as of the instant the invention is first used or manufactured by the [g]overnment." *Decca Ltd. v. United State*s, 640 F.2d 1156, 1166 (Ct. Cl. 1980). And, because the government has only waived sovereign immunity for a compulsory taking of a non-exclusive patent license, the basis for recovery under 28 U.S.C. § 1498 differs from that in patent litigation between private parties under 35 U.S.C. § 271 in the following respects:

> [S]ection 1498 is a waiver of sovereign immunity only with respect to a *direct governmental infringement* of a patent. Activities of the [g]overnment which fall short of direct infringement do not give rise to governmental liability because the [g]overnment has not waived its sovereign immunity with respect to such activities. Hence, the [g]overnment is not liable for its inducing infringement by others, for its conduct contributory to infringement of others, or for what, but for section 1498, would be contributory (rather than direct) infringement of its suppliers. Although these activities have a tortious ring, the [g]overnment has not agreed to assume liability for them.

Decca, 640 F.2d at 1167 (footnotes omitted) (emphasis added).

The government directly infringes a patent when it uses or manufactures the patented invention without a license. *See Decca*, 640 F.2d at 1167 n.15. In evaluating a patent infringement dispute under Section 1498, the court applies a two-step analysis that parallels the infringement analysis applied to disputes between private parties. *See Lemelson v. United States*, 752 F.2d 1538, 1548-49 (Fed. Cir. 1985); *Casler v. United States*, 15 Cl. Ct. 717, 731 (1988), *aff'd*, 883 F.2d 1026 (Fed. Cir. 1989). The court first construes the claims of the patent, and then compares the construed claims to the characteristics of the accused infringing product or process. *See JVW Enters., Inc. v. Interact Accessories, Inc*., 424 F.3d 1324, 1329 (Fed. Cir. 2005). Claim

construction is a question of law to be determined by the court, whereas the comparison between the claims and the accused product or process involves questions of fact. *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 388-90 (1996). In making such a comparison, the plaintiff has the burden of proving that every limitation in a patent claim is also present in the accused infringing product or process, either literally or through the doctrine of equivalents. *See Lemelson*, 752 F.2d at 1551 ("[E]ach element of a claim is material and essential, and . . . in order for a court to find infringement, the plaintiff must show the presence of every element or its substantial equivalent in the accused device.") (citations omitted); *Prochroma Techs., Inc. v. United States*, 60 Fed. Cl. 614, 617 (2004) (noting that plaintiffs must demonstrate evidence that the government "literally or equivalently" infringed the claim by meeting all of the claim's limitations) (citations omitted). This standard is commonly described as the "all elements" rule. *See TDM Am., LLC v. United States*, 92 Fed. Cl. 761, 768 (2010), *aff'd*, 471 Fed. Appx. 903 (Fed. Cir. 2012); *see also Warner-Jenkinson Co. v. Hilton Davis Chem. Co.*, 520 U.S. 17, 29 (1997). Ultimately, the plaintiff has the burden of proving direct infringement, literally or under the doctrine of equivalents, by a preponderance of the evidence. *Lemelson*, 752 F.2d at 1547; *Hughes Aircraft Co. v. United States*, 717 F.2d 1351, 1361 (Fed. Cir. 1983).

B. Available Defenses

Under Section 1498(a), "[i]n the absence of a statutory restriction, *any defense* available to a private party is equally available to the United States." *Motorola*, 729 F.2d at 769 (quoting 28 U.S.C. § 1498, Revisor's Notes) (alterations in original). Thus, the invalidity defenses available to private parties involved in patent disputes under 35 U.S.C. § 282(b) are also available to the government. *See, e.g.*, *Messerschmidt v. United States*, 29 Fed. Cl. 1, 17-40, (granting the government's cross-motion for summary judgment on plaintiff's patent infringement suit and invalidating plaintiff's patent on the basis of anticipation and obviousness), *aff'd*, 14 F.3d 613 (Fed. Cir. 1993). Nonetheless, because an issued patent is presumed valid, *see* 35 U.S.C. § 282(a), the government must prove invalidity by clear and convincing evidence, *Microsoft Corp. v. i4i Ltd. P'ship*, 564 U.S. 91, 95 (2011). This burden of persuasion remains on the government throughout a pending action. *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1534 (Fed. Cir. 1983).

Pursuant to Supreme Court precedent construing 35 U.S.C. § 101, "[l]aws of nature, natural phenomena, and abstract ideas" are subject matters that are not eligible for patent protection. *Alice Corp. Pty. Ltd. v. CLS Bank Int'l*, __ U.S. __, __, 134 S. Ct. 2347, 2354 (2014) (quoting *Association for Molecular Pathology v. Myriad Genetics, Inc.*, __ U.S. __, __, 133 S. Ct. 2107, 2116 (2013)).[13] Under the two-part test articulated in *Alice*, a court must (1)

[13]These three categories of ineligible subject matter are judicially created. *See Hitksansut III*, 115 Fed. Cl. at 723. The text of Section 101 states:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

35 U.S.C. § 101.

"determine whether the claims at issue are directed to one of those patent-ineligible concepts," and (2) if so, "consider the elements of each claim both individually and 'as an ordered combination' to determine whether the additional elements 'transform the nature of the claim' into a patent-eligible application." *Alice*, __ U.S. at __, 134 S. Ct. at 2355 (citing *Mayo Collaborative Servs. v. Prometheus Labs., Inc.*, __ U.S. __, __, 132 S. Ct. 1289, 1296-98 (2012)). The second step has been characterized as "a search for an 'inventive concept.'" *Id.* (citing *Mayo*, __ U.S. at __, 132 S. Ct. at 1294); *see also Synopsys, Inc. v. Mentor Graphics Corp.*, 839 F.3d 1138, 1146 (Fed. Cir. 2016).

Additionally, a patent is invalid due to obviousness when "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103(a) (2006).[14] The obviousness determination is a "legal conclusion," but is "based on underlying facts." *Allergan, Inc. v. Sandoz Inc.*, 726 F.3d 1286, 1290 (Fed. Cir. 2013) (citing *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17 (1966)). The factual underpinnings include: (1) the scope of content of the prior art, (2) the difference between the prior art and asserted claims, (3) the level of ordinary skill in the relevant art, and (4) the objective evidence of non-obviousness. *Graham*, 383 U.S. 1, 17-18 (1966); *see also KSR Int'l Co. v. Teleflex Inc*., 550 U.S. 398, 406-07 (2007). The party raising the obviousness defense has the burden of proving, by clear and convincing evidence, "that a skilled artisan would have had reason to combine the teaching of the prior art reference to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success from doing so." *PAR Pharm., Inc. v. TWI Pharm., Inc.*, 773 F.3d 1186, 1193 (Fed. Cir. 2014) (quoting *In re Cyclobenzaprine Hydrochloride Extended-Release Capsule Patent Litig.*, 676 F.3d 1063, 1068-69 (Fed. Cir. 2012) (in turn quoting *Procter & Gamble Co. v. Teva Pharm. USA, Inc.*, 566 F.3d 989, 994 (Fed. Cir. 2009))) (internal quotation marks omitted).

A patent is also invalid if it fails to satisfy the enablement requirement, which is set forth in 35 U.S.C. § 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

35 U.S.C. § 112, Paragraph 1 (2006). A patent is invalid due to lack of enablement when the party contesting the patent's validity demonstrates, by clear and convincing evidence, that "a person of ordinary skill in the art would not be able to practice the claimed invention without 'undue experimentation.'" *Alcon Research*, 745 F.3d at 1188 (citing *In re Wands*, 858 F.2d 731, 736-37 (Fed. Cir. 1988); *Johns Hopkins Univ. v. CellPro, Inc.*, 152 F.3d 1342, 1360 (Fed. Cir.

[14]Section 103 was also amended by the AIA. *See* AIA, 125 Stat. at 287. Subparagraph 3(n)(1) of the AIA makes the change to Section 103 applicable to any patent application filed 18 months after September 16, 2011, *i.e.*, subsequent to March 16, 2013. *See* 125 Stat. at 293. Accordingly, the pre-AIA version of Section 103 applies to this case.

1998)). The enabling disclosure must be in the specification of the patent at the time the patent application was filed. *MagSil Corp. v. Hitachi Glob. Storage Techs., Inc.*, 687 F.3d 1377, 1382 (Fed. Cir. 2012). Enablement is a question of law, but the court's analysis may be based on findings of fact. *Alcon Research*, 745 F.3d at 1188. Determining whether the necessary experimentation is "undue" requires the court to weigh "many factual considerations" and apply a standard of reasonableness, with consideration given to "the nature of the invention and the state of the art." *Wands*, 858 F.2d at 737 (citations omitted).

C. Compensation Under 28 U.S.C. § 1498

If the government directly infringes the plaintiff's patent, the plaintiff is entitled to recover the "reasonable and entire compensation" for the government's acquisition of a compulsory non-exclusive patent license. 28 U.S.C. § 1498(a); *see Decca*, 640 F.2d at 1167. "Generally, the preferred manner [for calculating reasonable and entire compensation] is to require the government to pay a reasonable royalty for its license as well as damages for its delay in paying the royalty." *Standard Mfg. Co. v. United States*, 42 Fed. Cl. 748, 758 (1999), *abrogated in other respects by Uniloc USA, Inc. v. Microsoft Corp.*, 632 F.3d 1292 (Fed. Cir. 2011); *see also Wright v. United States*, 53 Fed. Cl. 466, 469 (2002). In determining such a royalty, the court considers the "supposed result of hypothetical negotiations between the plaintiff and defendant." *Rite-Hite Corp. v. Kelley Co.*, 56 F.3d 1538, 1544 (Fed. Cir. 1995) (en banc) (citing *Hanson v. Alpine Valley Ski Area, Inc.*, 718 F.2d 1075, 1078 (Fed. Cir. 1983)). In this hypothetical negotiation, the court must "envision the terms of a licensing agreement reached as the result of a supposed meeting between the patentee and the infringer at the time infringement began," *id.*, which is deemed to be the date of first use or manufacture, *Brunswick Corp. v. United States*, 36 Fed. Cl. 204, 210 (1996), *aff'd*, 152 F.3d 946 (Fed. Cir. 1998). To supplement the court's analysis of a reasonable royalty in the context of a hypothetical negotiation, the court may rely on the factors provided in *Georgia-Pacific Corp. v. United States Plywood Corp.*, 318 F. Supp. 1116, 1120 (S.D.N.Y. 1970), *modified and aff'd*, 446 F.2d 295 (2d Cir. 1971). *See Maxwell v. J. Baker, Inc.*, 86 F.3d 1098, 1109-10 (Fed. Cir. 1996). The factors are:

> (1) current, established royalty rates under the patent at issue; (2) royalty rates for comparable technology; (3) scope, exclusivity, and restrictiveness of a retroactive license; (4) the patent holder's established licensing and marketing practices; (5) commercial/competitive relationship of licensor and licensee; (6) derivative/convoyed sales of unpatented, accompanying materials by patentee and competitors; (7) duration of patent and license terms; (8) profitability and commercial success of invention; (9) utility and advantages of invention over prior art; (10) nature, character, and benefits of use; (11) extent and value of infringing use; (12) allocation of a portion of profits or sales for use of invention; (13) portion of realizable profits creditable to the invention alone; (14) expert testimony on royalty rates; and (15) the totality of other intangibles impacting a hypothetical negotiation between a willing licensor and licensee.

Brunswick Corp., 36 Fed. Cl. at 211 (citing *Georgia-Pacific Corp.*, 318 F. Supp. at 1120). However, the court is not "constrained" by these factors and need not consider factors that are

"inapposite or inconclusive." *Id.* at 211-12. Ultimately, the court's reasonable royalty analysis is "highly case-specific and fact-specific" and involves "mixed considerations of logic, common sense, justice, policy and precedent." *Boeing Co. v. United States*, 86 Fed. Cl. 303, 311 (2009) (internal quotation marks and citations omitted).

ANALYSIS

Hitkansut filed suit against the government under 28 U.S.C. § 1498(a), alleging that Oak Ridge's TMP method directly infringes, either literally or under the doctrine of equivalents, independent Claims 1 and 11 and dependent Claim 6 of the '722 patent. Pls.' Post-Trial Br. at 15-42, ECF No. 221. The government asserts that the activities at Oak Ridge do not infringe any of the asserted claims in the '722 patent, and also contests the validity of the '722 patent on the grounds of patent-ineligible subject matter, obviousness, and lack of enablement. Def.'s Post-Trial Br. at 6-38. Additionally, if Oak Ridge is found to have infringed the '722 patent, Hitkansut claims that its "reasonable and entire compensation" would total approximately $5.6 million, Pls.' Post-Trial Br. at 43-60, whereas the government states that Hitkansut would only be entitled to approximately $200,000, Def.'s Post-Trial Br. at 38-60. In resolving this dispute, the court's initial task is to determine whether the activities at Oak Ridge directly infringe the foregoing claims in the '722 patent.

I. INFRINGEMENT

A. Independent Claim 1 and Dependent Claim 6

Hitkansut asserts that Oak Ridge's TMP method literally infringes independent Claim 1 and associated dependent Claim 6 of the '722 patent. Pls.' Post-Trial Br. at 18-36.[15] To prove literal infringement, Hitkansut must demonstrate that the TMP method embodies each and every element in Claim 1. *See ZMI Corp. v. Cardiac Resuscitator Corp.*, 844 F.2d 1576, 1578 (Fed. Cir. 1988) (citations omitted). If the language provided in Claim 1 reads directly on the TMP method, "the court may disregard additional components or elements of the [method] if those additions do not produce a radically different result." *Judin v. United States*, 27 Fed. Cl. 759, 784 (1993); *see also Becton Dickinson & Co. v. C.R. Bard, Inc.*, 922 F.2d 792, 797 (Fed. Cir. 1990). The government counters that Hitkansut has failed to show infringement of every element set forth in Claim 1, Def.'s Post-Trial Br. at 7-16, 17-21, as detailed in the government's four objections below.

1. *Limitation [a]: "[P]roviding a first energy to a structure by performing a first energy process according to an operational setting,* ***at least one of the operational setting and a time value being selected according to a first order rate relationship for the first energy process, according to a first order rate relationship for a second energy process****, and according to a desired physical property value."*

[15]The government concedes that only the limitations of Claim 1 are at issue here and not those of Claim 6, which depends upon Claim 1 and only includes one additional limitation that the government does not contest. *See* Def.'s Post-Trial Br. at 7 n.6.

The parties dispute whether Oak Ridge selected its operational settings according to a "first order rate relationship" for the first and second energy processes. Hitkansut asserts that Oak Ridge selected its operational settings, which include time, temperature, and magnetic field strength, according to a first order rate relationship for the first energy process, thermal energy, and for the second energy process, oscillatory energy. *See* Pls.' Post-Trial Br. at 20-24. The government responds that a first order rate relationship does not apply to Oak Ridge's TMP process. Def.'s Post-Trial Br. at 12.

The court construed "first order rate relationship" to mean "a mathematical relationship between the application of an energy to a structure and the responsive change in the structure that varies with the value of one variable, and where the rate of change in the variable is exponential such that a plot of the natural logarithm over time results in a straight line." *Hitkansut II*, 114 Fed. Cl. at 419. In arguing that Oak Ridge's TMP method does not reflect a first order rate relationship, the government primarily relies upon the testimony of Dr. Ludtka. Dr. Ludtka testified that Oak Ridge's TMP method produces a constant of 12.6 Joules per mole per Tesla,[16] which "is a zero order [relationship], not a first order relationship." Tr. 1961:5-13 (Ludtka); *see also* Tr. 2168:3-18 (Test. of Dr. Alan P. Druschitz, defendant's technical expert) (relying on DX 37 (Gerard M. Ludtka, *Exploring Ultrahigh Magnetic Field Processing of Materials for Developing Customized Microstructures and Enhanced Performance* (Mar. 2005)) at 37.19).[17]

The government's argument sidesteps the relevant point. As Hitkansut notes, the constant cited by Dr. Ludtka and Dr. Druschitz refers to the strength of the magnetic field. *See* Pls.' Post-Trial Reply Br. at 9, ECF No. 228; DX 37 at 37.19. The TMP method, in contrast, involves more than a magnetic field; it encompasses thermal energy from the induction heater, oscillatory energy created by the interaction between the induction heater and magnetic field, and application of both for a time value at the constant high magnetic field. *See*, *e.g.*, PX 175. In applying these energies concurrently through the TMP process, Dr. Kisner, a researcher at Oak Ridge and a colleague of Dr. Ludtka, testified that Oak Ridge sought to determine rate of change over time and used graphs measuring temperature versus time. Tr. 717:4-16 (Kisner) (explaining that the graphs demonstrated "effects occurring over time as the material's energy changed in connection with the application of a magnetic field"). Dr. Robert Wagoner, Hitkansut's technical expert, explained that "[o]ne of ordinary skill[18] would know that the evolution of physical properties of metals with time follows a first-order rate relationship." PX 422 (Expert

[16]The Tesla is a unit of measurement of the strength of a magnetic field. The Joule is a unit of measurement of work or energy.

[17]Dr. Druschitz is an associate professor of materials science engineering at Virginia Polytechnic Institute and State University. *See* DX 3 (Invalidity Report of Alan P. Druschitz, Ph.D.) at D3.3. The court accepted Dr. Druschitz as an expert qualified in metallurgical engineering. Tr. 2061:7-9.

[18]The parties "agree that a person or ordinary skill in the art would possess a [b]achelor's degree in materials science, engineering, or a related field, and some practical experience working with solid materials." Def.'s Post-Trial Br. at 33.

Report of Robert H. Wagoner, Ph.D. on Infringement, Appendix D) at 4 (footnotes omitted).[19] Additionally, Dr. Wagoner found that Oak Ridge made "use of linear fits to property-vs.-log (time) plots, consistent with analysis using a first-order relationship." *Id.* at 6-9 (citing PX 31 (Department of Energy, Final Technical Report, *Prototyping Energy Efficient Thermo-Magnetic & Induction Hardening for Heat Treat & Net Shape Forming Applications* (July 30, 2012))). Oak Ridge's graphs and plots are in harmony with the court's construction of first order rate relationship. Hitkansut has thus demonstrated that Oak Ridge's TMP method reflects use of a first order rate relationship.

If Oak Ridge's TMP process involves a first order rate relationship, as the court finds it does, the government nonetheless contends that Oak Ridge's settings were not "selected" according to a first order rate relationship. *See* Def.'s Post-Trial Br. at 9-12.[20] The government states that "merely using empirical data is not sufficient." *Id*. at 10. Rather, in the government's view, the "selected" term within Claim 1 requires a "knowing use of a Larson-Miller relationship obtained from the empirical data." *Id.* In contrast, Hitkansut asserts that the temperature or time setting only needs to be "chosen in view of" a first order rate relationship. Pls.' Post-Trial Br. at 20.

The court construed the "selected" limitation to mean "choosing a set point or time value for a first order rate relationship for the first energy process and for a first order rate relationship for the second energy process, to achieve a desired physical property value." *Hitkansut II*, 114 Fed. Cl. at 421. The relevant first order rate relationship need not be selected according to a Larson-Miller equation as such; instead, it may be "determined based upon plots of experimental data, *i.e*., in essence from experiments, the results of which define a part of the relationship empirically." *Id*. at 425. In these aspects, the "selected" limitation need not meet the "knowing" requirement the government attempts to impose. By using that word, the government would impart more knowledge about the nature of the first order rate relationship than the patent's claim requires. Specifically, the government would use "knowing" to require some implicit but indefinite references to Larson-Miller equations or to plots of data specifically acknowledged by the researchers to be reflective of a Larson-Miller relationship. That goes too far. Such a "knowing" requirement does not appear in the language of the asserted claims or in the court's claim construction. As Dr. Wagoner explained, there are two separate and independent ways in which operational settings can be "selected" according to a first order rate relationship: (1) a theoretical method and (2) an experimental method. Tr. 950:11 to 951:3 (Wagoner). Under the theoretical method, data or results from other comparable processes can used to estimate or

[19]Dr. Wagoner is a professor emeritus of materials science and engineering at the Ohio State University, who had been department chair of the materials science and engineering department. *See* PX 418 (Expert Report of Robert H. Wagoner, Ph.D. on Infringement) at 2. Dr. Wagoner was accepted by the court as an expert in metallurgy and metallurgical engineering. Tr. 920:3-6. His expert report on infringement was admitted into evidence.

[20]In presenting its argument, the government reads the "selected" term of element [a] in conjunction with element [j] of Claim 1, which states that the first order rate relationship is a Larson-Miller relationship. *See* Def.'s Post-Trial Br. at 7-12. The court addresses element [j] and the Larson-Miller relationship *infra*.

project the appropriate operational settings for a process at hand based on Larson-Miller relationships. *See* Tr. 950:15-18 (Wagoner); PX 422 at 4. Under the experimental method, operational settings are adjusted, *i.e.*, "selected," based upon the results of some prior experiments using a particular process, not necessarily the full spectrum of experiments needed to establish the relationship on a comprehensive footing. *See* Tr. 950:19-24 (Wagoner); PX 422 at 4. The so-called "experimental method" would suffice to provide a basis for the selection contemplated by elements [a] and [i] of Claim 1.

Given the court's construction of the term "selected" within Claim 1 and Dr. Wagoner's testimony, Hitkansut has sufficiently demonstrated that Oak Ridge selected its operational settings according to a first order rate relationship. Specifically, Oak Ridge used prior experimental results to adjust the operational settings for its further work. *See* Tr. 507:5-18 (Wilgen) (agreeing that operational settings were altered based on past experiments, depending on the result Oak Ridge sought to achieve); Tr. 735:10-24 (Kisner) (explaining that, for example, temperature might be adjusted after examining the data from a past experiment because the settings were "driven by the experimental results"). To maximize energy efficiency, Oak Ridge performed repeated experiments and relied upon the results of such experimentation to determine optimal or appropriate metal processing methods. *See, e.g.*, PX 161 (Gerard M. Ludtka, et al., *Use of High Magnetic Field to Control Microstructural Evolution in Metallic and Magnetic Materials* (June 27, 2010)) (relying upon the results of past Oak Ridge experiments to establish the settings for the TMP method); PX 162 (Gail Mackiewicz Ludtka, et al., *Magnetic Processing – A Pervasive Energy Efficient Technology for Next Generation Materials for Aerospace and Specialty Steel Markets* (Sept. 10, 2010)) (relying upon past results to develop a materials processing method that increases energy efficiency).[21]

2. *Limitation [a]: "[P]roviding a first energy to a structure by performing a first energy process according to an operational setting,* ***at least one of the operational setting and a time value being selected*** *according to a first order rate relationship for the first energy process, according to a first order rate relationship for a second energy process, and* ***according to a desired physical property value."***

The government also disputes whether Oak Ridge selected its operational settings "according to a desired physical property *value*." Def.'s Post-Trial Br. at 13 (emphasis in original). According to the government, Hitkansut relies on data that Oak Ridge generated using the TMP process, but overlooks the fact that Oak Ridge does not select settings based on desired property values. *Id.* at 13; *see also* DX 16 (Non-Infringement Report of Alan P. Druschitz, Ph.D.) at 16.14 (opining that Hitkansut failed to show that Oak Ridge used "calculations or

[21]While the first order rate relationship needed to establish operational settings can be derived theoretically in a relatively simple manner for a thermal energy, it is more difficult to determine a first order rate relationship theoretically for an oscillatory energy or the variant of an oscillatory energy created by the TMP process. A constant for an equation or relationship regarding the TMP oscillatory energy would need to be derived through experimentation. Similarly, experimentation would be required to establish the constant for, and first order relationship representing, the concurrent application of energies employed in the TMP process, which in effect is what Oak Ridge did by relying on plots of data.

determinations of operational settings to achieve a desired physical property value. . . ."). Dr. Ludtka testified that Oak Ridge was only trying to "characterize" and "maximize" the TMP process to "defin[e] the parameter space," rather than to "optimize" the TMP process. Tr. 1962:1 to 19:63:17 (Ludkta). Putting aside whether there is a meaningful difference between "maximize" and "optimize" in this context, the government in effect claims that Oak Ridge has been only attempting to determine the parameters of the TMP method, not to achieve a particular result or property value. Def.'s Post-Trial Br. at 13.

The government's argument is unpersuasive. The court construed the term "desired physical property value" to mean "a result or change in the physical condition of a structure that is sought from subjecting the structure to processing." *Hitkansut II*, 114 Fed. Cl. at 420. In doing so, the court rejected the government's contention that the term "desired physical property value" should be construed as "a numeric value that represents the amount of change or condition of the structure after treatment." *Id.* (internal quotation marks omitted). Consistent with the court's construction, Hitkansut has demonstrated that Oak Ridge sought to achieve changes in the physical condition of a structure and selected its TMP process according to the physical property it was measuring. *See* Pls.' Post-Trial Br. at 24; Pls.' Post-Trial Reply Br. at 9-10. For example, Dr. Kisner testified that in conducting TMP research, he tried "to achieve a particular change in a particular physical property in advance of the experiment," Tr. 737:24 to 738:2 (Kisner), and measured the results to determine whether the experiment did in fact achieve that change, Tr. 738:3-7 (Kisner); *see also* Tr. 507:5-18 (Wilgen) (agreeing that operational settings were altered based on past experiments, depending on the result Oak Ridge sought to achieve); Tr. 878:10-22 (Kisner) (agreeing that the TMP settings for the induction heater and magnet were determined based on the physical property change Oak Ridge sought to achieve). Dr. Wilgen further testified that Oak Ridge determined the temperature and time needed "to achieve the desired initial conditions so that the quench phase could proceed productively with the desired outcome." Tr. 506:7-11 (Wilgen). Oak Ridge's research reports and award entries support this testimony. *See, e.g.*, PX 31 at 7 ("The use of a coupled induction heat treatment with high magnetic field heat treatment makes possible not only improved performance alloys, but with faster processing times and lower processing energy, as well."); PX 45 at 3 ("Thermomagnetic processing . . . changes basic materials microstructures, phase transformation (equilibrium and kinetics) responses, has a chemical catalytic synthesis effect, and can yield orders of magnitude improvement in mechanical behavior and end-use performance of the components processed by this technology.").

Additionally, Hitkansut correctly notes that Oak Ridge did in fact "optimize[the] tempering process to achieve the maximum kinetic benefit." Pls.' Post-Trial Reply Br. at 10. Oak Ridge performed repeated experiments and relied on the results of prior experimentation to determine the optimal metal processing method. *See, e.g.*, PX 161; PX 162; Tr. 735:5-24 (Kisner). Dr. Ludkta also testified that he "scale[d] back" on the TMP process because of an "acceleration of kinetics" when superimposing the magnetic field over a conventional heat treat process during tempering resulted in severe overtempering such "that the [material's] properties degrade[d]." Tr. 1963:20 to 1964:7 (Ludtka). Dr. Wagoner explained that "[t]he entire purpose of the TMP process is to modify the physical/mechanical properties of materials in a beneficial way, particularly faster and/or at lower temperature[,] thus saving energy and conferring other advantages." PX 422 at 3.

3. *Limitation [j]: "wherein the first order rate relationship for the first energy process is a first **Larson[-]Miller relationship** that relates application of thermal energy to the structure and the physical property, and wherein the first order rate relationship for the second energy process is a second **Larson[-]Miller relationship** that relates application of oscillatory energy to the structure and the physical property."*

The government next challenges whether Oak Ridge selected its operational settings according to a Larson-Miller relationship. Def.'s Post-Trial Br. at 9-12.[22] The government argues that Oak Ridge adjusted the temperature in its experiments by using empirical results without reference to a Larson-Miller relationship. Def.'s Post-Trial Br. at 11 (citing Tr. 717 to 735 (Kisner)). In support, the government's expert, Dr. Druschitz, opined that Hitkansut failed to show that Oak Ridge used any Larson-Miller relationships relating a physical property of a structure to a first or second energy. DX 16 at 16.14. Additionally, Dr. Ludtka testified that in conducting TMP research, Oak Ridge never used a Larson-Miller equation or relationship. Tr. 1961:15-24 (Ludtka).

The government's argument, however, is not consistent with the court's claim construction. The court construed "Larson-Miller relationship" to mean "a parametric representation of a system of physical properties of a structure subjected to energy processes, which *can* take the form of the equation $P = {}^{\Delta H}/_{R} = T\,(C + \log t)$." *Hitkansut II*, 114 Fed. Cl. at 426 (emphasis added).[23] In that equation, P is a constant, T represents absolute temperature, and t represents time. Larson & Miller, *Rupture & Creep Stresses*, at 765. During claim construction, the parties disagreed over whether the term "Larson-Miller relationship" requires reference to the Larson-Miller equation. *Hitkansut II*, 114 Fed. Cl. at 425. The court rejected the government's proposed construction and determined that reference to an equation is not required, explaining:

> The government's interpretation ignores that parameters determined by a Larson-Miller relationship are not limited to those derived explicitly from an equation. Parameters may be determined based upon plots of experimental data, *i.e.*, in essence from experiments, the results of which define a part of the relationship empirically. That indeed was the approach taken by Larson and Miller in their

[22]To the extent that the government relies upon its interpretation of the term "selected" in element [a] as requiring "a knowing use of a Larson-Miller relationship," Def.'s Post-Trial Br. at 10, the court rejects such an interpretation for the reasons set forth in the court's analysis of element [a] of Claim 1, addressed *supra*.

[23]The equation set forth in the court's construction order is the same equation Larson and Miller provided in their seminal article. Larson & Miller, *Rupture & Creep Stresses*, at 765-75. Larson and Miller introduced the Larson-Miller relationship as a way to "describe[] a time and temperature relationship for relieving creep stress and preventing catastrophic failure or rupture." *Hitkansut V*, 119 Fed. Cl. at 266 n.14; *see also* Larson & Miller, *Rupture & Creep Stresses*, at 770. "Creep is the continuous deformation of metals at high temperature at a constant stress." PX 427 (Expert Rebuttal Report of Robert H. Wagoner, Ph.D., on Validity) at 14 n.6.

> seminal paper. . . . The patent specification confirms that this possibility is contemplated in, and encompassed by, the patent. *See* '722 patent, col. 6, lines 16-17, 23-26, 30-41.

Id. Thus, even if Oak Ridge did not explicitly identify a Larson-Miller relationship in terms of an equation during the course of its research, that alone would not absolve Oak Ridge of infringement liability. The court must instead determine whether Oak Ridge set parameters based upon the Larson-Miller equation explicitly *or* "based upon plots of experimental data, . . . the results of which define a part of the relationship empirically." *Id.*

In this context, the parties additionally dispute whether the doctrine of equivalents applies based upon the correlation of the Larson-Miller equation with the Arrhenius equation. Pls.' Post-Trial Br. at 34, 40-41; Def.'s Post-Trial Br. at 17-21. The '722 patent does not claim the Arrhenius equation, but the specification does refer to it, explaining that "[g]enerally, the rate of stress relief obtained using thermal methods is driven by diffusion and can be described using the Arrhenius first order rate equation . . . $r(T) = Ae^{-\Delta H/RT}$." '722 patent, col. 7, lines 52-58; *see also* PX 422 at 36 ("One of ordinary skill would understand that a thermally-activated first-order reaction is a relationship between time (t) and temperature (T), typically written in rate form as an Arrhenius equation (reaction rate form, rate vs. T)."). The Larson-Miller equation can be mathematically derived from the Arrhenius equation, *see* '722 patent, col. 6, lines 21-23; Tr. 1003:10-15 (Wagoner), and "is a variant of the Arrhenius equation as applied in physics rather than chemistry," *Hitkansut II*, 114 Fed. Cl. at 420.

The government concedes that the Larson-Miller relationship is similar to the Arrhenius equation, but it avers that the two are "not the same." Def.'s Post-Trial Br. 19 n.11; Tr. 2164:7-22 (Druschitz). Further, the government contends that prosecution history estoppel precludes Hitkansut from claiming that the two equations are equivalent first order rate relationships, arguing that Hitkansut narrowed the scope of Claim 1 in element [j] by amending "first order rate relationship" to refer to a "Larson-Miller relationship" and thereby overcome an obviousness rejection by the patent examiner. Def.'s Post-Trial Br. at 19-21; *see also Festo Corp. v. Shoketsu Kinzoku Kogyo Kabushiki Co.*, 535 U.S. 722, 733-34 (2002) ("When . . . the patentee originally claimed the subject matter alleged to infringe but then narrowed the claim in response to a rejection, he may not argue that the surrendered territory comprised unforeseen subject matter that should be deemed equivalent to the literal claims of the issued patent.").[24]

The government's argument is misplaced. Rather than claiming or emphasizing a Larson-Miller *equation*, the '722 patent claims a "Larson Miller *relationship*" in element [j] of Claim 1 after referring consistently to "first order rate relationship" in the prior elements of Claim 1. '722 patent, col. 19, lines 48-49, 56, 59; col. 20, lines 10, 14 (emphasis added). The

[24]As the government itself notes, the examiner explained that the concurrent combination of thermal and oscillatory processes followed the Larson-Miller relationship, which was "critical." "In view of the declaration filed on April 3, 2006, . . . Exhibits D and E have shown that the combination of parameters determined by Larson-Miller and combined thermal and vibration process[es are] critical and reduce residu[al] stress." DX 2 (prosecution history of the '722 patent) at 2.364. *See* Def.'s Post-Trial Br. at 20.

broader term "relationship" is significant because it encompasses more than simply a Larson-Miller equation. *Hitkansut II*, 114 Fed. Cl. at 425. The Larson-Miller and Arrhenius equations are rate functions that are derivable from one another, Tr. 1003:10-15 (Wagoner); Tr. 2164:7-22 (Druschitz), and represent alternative representations of the same thermally-activated first order rate relationship between temperature and time. PX 422 at 36 ("The first order Arrhenius equation is in rate form whereas the Larson-Miller equation is in integral form."). And while the two equations are not identical, they both serve to "define the connection between temperature and reaction time or temperature and reaction rate." *Id.* at 36. Thus, the government's estoppel claim is misplaced because both the Arrhenius and Larson-Miller equations fall within the patent's broader claim to a first order rate *relationship*, including a Larson-Miller relationship, as construed by the court.

Given these considerations, the court finds that Oak Ridge selected its operational settings according to a Larson-Miller relationship. As discussed *supra* in the context of a first order rate relationship, Hitkansut may demonstrate infringement by showing that Oak Ridge selected settings through an experimental method. Here, Oak Ridge applied and adjusted time and temperature operational settings according to past experimental results. *See* Tr. 735:10-24 (Kisner). In selecting such settings, Oak Ridge relied upon rates of change and the hardness of the material. *See* Tr. 717:4-16 (Kisner) (explaining that Oak Ridge prepared graphs measuring temperature and time); PX 65 (e-mail from Dr. Ludtka to Raymond G. Boaman (Aug. 11, 2009, 1:45 p.m.)) at ORL103-005530 (stating that the TMP method could create energy savings by achieving "the same normal strength level but in shorter times or at lower heat treatment temperatures"); PX 161 at H0014098 (stating that Oak Ridge's TMP method processed time and temperature for hardness). Oak Ridge also plotted data in log time. *See* Tr. 776:16 to 777:13 (Kisner); PX 77 (Gerard M. Ludtka, et al., *High- And Themo-Magnetic Field Processing (HMFP)*: *A Transformational, Game-Changing Technology for the Next Generation Structural and Functional Materials with Superior Performance*) at ORL200-000235. The TMP process allows Oak Ridge to accelerate phase kinetics and improve processing efficiency by reducing either the time or temperature needed to process metal, in comparison to standard heat treatment. Tr. 773:21 to 775:16 (Kisner). As Hitkansut explained in its brief, "whether [Oak Ridge] actually knows the Larson-Miller relationship between the settings it selects and the desired physical property value, it selects settings to achieve an accelerated physical property value – the heart of the Larson-Miller equation and its (log t) term." Pls.' Post-Trial Reply Br. at 7-8; *see also* PX 31 at 23, 27-29 (stating that Oak Ridge's TMP method could decrease tempering time from "two hours to only ten minutes" and plotting data in log time).[25]

4. *Limitations [f] and [h]: "[W]herein* ***the first and second energies are different****," and "wherein the first energy is thermal and wherein the second energy is oscillatory."*

[25]Additionally, although a reference to an equation is not required to find infringement, the Larson-Miller equation was in fact identified in the PCT application that listed Dr. Ludtka as an inventor. PX 510 at 8 ("The following tempering parameter is often used to describe the interaction between time and temperature: $T\,(20 + \log t) \times 10^{-3}$ where T is temperature in Kelvin and t is time in hours.").

In its final challenge regarding infringement of Claim 1, the government disputes whether Oak Ridge's TMP process utilized two different energies. Hitkansut asserts that the TMP process applies two separate and distinct energies concurrently: (1) thermal energy from the induction heater and (2) oscillatory energy resulting from the interaction between the induction heater and high magnetic field. Pls.' Post-Trial Br. at 28; Pls.' Post-Trial Reply Br. at 11. The government does not dispute Oak Ridge's application of thermal and oscillatory energies, but rather claims that the thermal and oscillatory energies applied at Oak Ridge are not different because both "are manifestations of the same energy source: the Alternating Current (AC) in the induction heater." Def.'s Post-Trial Br. at 14.

The government's position is not consistent with the language of Claim 1 and the court's construction of the relevant terms. The court construed the term "energy" to mean "the capacity to do work by various means, here, specifically, the capacity or capability to act on a structure." *Hitkansut II*, 114 Fed. Cl. at 417. In doing so, the court explicitly chose not to limit its construction to particular energy sources, even by way of examples as the government had proposed during claim construction. *Id.* Further, the court construed "energy process" to mean "a method of imparting a type of work to a structure." *Id.* at 418. Thus, the fact that one of Oak Ridge's energies originates from two sources, reflecting an oscillatory effect obtained through use of an induction heating coil placed in the core of a high-energy magnet, does not absolve Oak Ridge from infringing Claim 1. Hitkansut has demonstrated that Oak Ridge applies two distinct energies that act on a structure: a thermal energy through induction heating and an oscillatory energy created by the induction heating coil interacting with the magnetic field. *See, e.g.*, PX 175 at ORL019-14189; Tr. 726:21 to 727:3 (Kisner).

Thus, for the reasons stated, the court finds that Hitkansut has proven by a preponderance of the evidence that Oak Ridge's TMP method literally infringes independent Claim 1, as well as dependent Claim 6.[26]

B. Independent Claim 11

Hitkansut further avers that Oak Ridge's TMP method literally infringes independent Claim 11. Pls.' Post-Trial Br. at 36-42. Claim 11 is similar to Claim 1 in that both rely on the "use of a combined first order relationship relating concurrent application of two energy processes to a desired physical property value," *Hitkansut III*, 115 Fed. Cl. at 733, but unlike Claim 1, Claim 11 is not limited to the application of thermal and oscillatory energies, *id.* at 734. Similar to its arguments regarding Claim 1, the government asserts that Hitkansut failed to prove infringement of every element of Claim 11, specifically basing its contentions on application of the terms "desired physical property value" (element [d]), "according to a first order rate relationship" (element [d]), and "determining the Larson[-]Miller relationship" (element [e]). Def.'s Post-Trial Br. at 16-17.

[26]The court consequently reserves and does not address the parties' dispute over whether the doctrine of equivalents would support a finding of infringement.

1. *Limitation [d]: "[W]herein one of the operational setting and the time value are selected* ***according to a desired physical property value and according to a first order rate relationship*** *that relates concurrent application of the first and second energy to the structure and the physical property of the structure."*

As presented in Claim 1, the government disputes whether Oak Ridge made its selections according to a desired physical property value and according to a first order rate relationship. Def.'s Post-Trial Br. at 16. For the reasons discussed *supra*, the court finds that Hitkansut has demonstrated that Oak Ridge selects its operational settings according to a desired physical property value and according to a first order rate relationship. Further, that first order rate relationship pertains to concurrent application of two energies, thermal and oscillatory, to the structure and physical properties of the structure, *see, e.g.*, PX 139; PX 175, which the government does not contest, *see* Def.'s Post-Trial Br. at 16.

2. *Limitation [e]: "[F]urther comprising* ***determining the Larson[-]Miller relationship*** *that relates concurrent application of the first and second energy to the structure and the physical property of the structure."*

The government avers that Oak Ridge does not determine the Larson-Miller relationship that relates concurrent application of the first and second energies. Def.'s Post-Trial Br. at 16-17. The government focuses on the term "determining" within this element of Claim 11, arguing that Oak Ridge "must actually 'determine' the Larson-Miller relationship" and challenging "Dr. Wagoner's theory that the Larson-Miller relationship need not be known." *Id.* at 17.

The government's argument is not supported by the court's findings. As discussed *supra*, the court construed "Larson-Miller relationship" to encompass more than a Larson-Miller equation and explained that the parameters of the relationship can be "based upon plots of experimental data, . . . the results of which define a part of the relationship empirically." *Hitkansut II*, 114 Fed. Cl. at 425. The government's attempt to impose a "knowledge" requirement in this context that the plot of data must be recognized as, and known to be, a Larson-Miller relationship is not consistent with the court's claim construction or the language of Claim 11. Oak Ridge determines the relationship of the concurrent application of the first and second energies by setting parameters based on prior experimental results, plotting and graphing the data obtained, and using these data to determine operational settings.

For the reasons stated, the court finds that Hitkansut has proven by a preponderance of the evidence that Oak Ridge's TMP method literally infringes independent Claim 11.

II. VALIDITY

A. Patent-Eligible Subject Matter

Regarding patent validity, the government first avers that the asserted claims in the '722 patent are invalid due to lack of patent-eligible subject matter. Def.'s Post-Trial Br. at 21-27. The exclusionary precept derived from 35 U.S.C. § 101 provides that "[l]aws of nature, natural phenomena, and abstract ideas are not patentable." *Alice*, __ U.S. at __, 134 S. Ct. at 2354

(internal quotation marks and citations omitted). As the Supreme Court has explained, "basic tools of scientific and technological work" are not patentable because, in part, the "monopolization of those tools through the grant of a patent might tend to impede innovation more than it would tend to promote it." *Mayo*, __ U.S. at __, 132 S. Ct. at 1293 (quoting *Gottschalk v. Benson*, 409 U.S. 63, 67 (1972)). Concurrently, the Supreme Court has recognized "that too broad an interpretation of this exclusionary principle could eviscerate patent law" because "all inventions at some level embody, use, reflect, rest upon, or apply laws of nature, natural phenomena, or abstract ideas." *Id.*; *see also Alice*, __ U.S. at __, 134 S. Ct at 2354 ("[W]e tread carefully in construing this exclusionary principle lest it swallow all of patent law."). With these principles in mind, the court applies the two-part test explicated in *Alice*, *i.e.*, first, "determin[ing] whether the claims at issue are directed to one of th[e] patent- ineligible concepts," and, second, "consider[ing] the elements of each claim both individually and 'as an ordered combination' to determine whether the additional elements 'transform the nature of the claim' into a patent-eligible application." __U.S. at __, 134 S. Ct. at 2355 (quoting *Mayo*, __U.S. at __, 132 S. Ct. at 1296-98).[27] In doing so, the court considers the claim elements both individually and as a whole. *Id.* at 2355 n.3 (citing *Diamond v. Diehr*, 450 U.S. 175, 188 (1981)).

Under step one of the *Alice* test, the government contends that the asserted claims in the '722 patent are directed to a patent-ineligible abstract idea, specifically "an algorithm for determining an operational setting and time values for two energy processes by use of the . . . Larson-Miller relationship." Def.'s Post-Trial Br. at 22. In presenting its argument, the government relies upon an equation set forth in the specification of the '722 patent, which has been quoted within the factual findings of this opinion and is also set out here:

> [T]he first L[arson]-M[iller ("L-M")] parameter may be determined according [to] a first L-M relationship (*e.g.*, L-M curve, etc.), wherein a desired remaining internal stress value is selected along the Y axis of the first L-M curve, and the corresponding parameter ("*P*") value is ascertained along the X axis (P_1). A second L-M parameter is determined for the desired physical property value according to a second L-M relationship (*e.g.*, a second L-M curve) by locating the desired internal stress value on the Y axis of the second L-M curve, and locating the corresponding second parameter value (*e.g.*, P_2) along the X axis. A third L-M parameter (*e.g.*, P_3) may optionally be determined according to the first and

[27]Hitkansut attempts to limit the *Alice* test to patents related to computer software, Pls.' Post-Trial Reply Br. at 14, but Hitkansut fails to provide adequate support for such a limitation. The *Alice* test has been applied in various other contexts, *see, e.g.*, *Rapid Litig. Mgmt. Ltd. v. CellzDirect, Inc.*, 827 F.3d 1042, 1046-52 (Fed. Cir. 2016) (applying the *Alice* test to a patent for a "method of producing a desired preparation of multi-cryopreserved hepatocytes"); *In re Smith*, 815 F.3d 816, 818-19 (Fed. Cir. 2016) (applying the *Alice* test to a patent "directed to rules for conducting a wagering game"), and there is nothing inherent in the *Alice* test that would limit it to computer software.

> second L-M parameters (P_1 and P_2), such as by subtraction (*e.g.*, $P_3 = P_1$-P_2). An operational setting and a time value are then selected according to [P_3]. . . .

'722 patent, col. 3, lines 22-36. According to the government, the relationship expressed in the $P_3 = P_1$-P_2 equation may be novel, but it is nonetheless an abstract idea. Def.'s Post-Trial Br. at 23. The equation relies on underlying algorithms and principles, including the Larson-Miller relationship and activation energy, but the government asserts that such reliance is insignificant because those algorithms and principles are merely descriptions of natural laws. *Id.* at 24.

Although the asserted claims of the '722 patent encompass descriptions of natural laws, such as the mathematical concepts embodied within the Larson-Miller relationship, the government misinterprets the *Alice* test. The relevant inquiry is not whether the claims encompass ineligible subject matter, but whether the claims are "*directed to*" ineligible subject matter. *See CellzDirect*, 827 F.3d at 1048-49 (emphasis added). In *CellzDirect*, the Federal Circuit addressed the eligibility of a patent related to "the ability of hepatocytes," a type of liver cell, "to survive multiple freeze-thaw cycles." *Id.* at 1045, 1048. Without needing to address the district court's determination that the hepatocytes' ability to survive multiple cycles was a natural law, the Federal Circuit found that the claims of the patent were "directed to a new and useful laboratory technique for preserving hepatocytes" and were therefore not directed to ineligible subject matter. *Id.* at 1048. The court elaborated on this theme:

> Indeed, the claims recite a "*method of producing* a desired preparation of multi-cryopreserved hepatocytes." '929 patent col. 19 l. 56-col. 20 l. 20 (emphasis added). Through the recited steps, the patented invention achieves a better way of preserving hepatocytes. The '929 patent claims are like thousands of others that recite processes to achieve a desired outcome, e.g., methods of producing things, or methods of treating disease. That one way of describing the process is to describe the natural ability of the subject matter to *undergo* the process does not make the claim "directed to" that natural ability. If that were so, we would find patent-ineligible methods of, say, producing a new compound (as directed to the individual components' ability to combine to form the new compound), treating cancer with chemotherapy (as directed to cancer cells' inability to survive chemotherapy), or treating headaches with aspirin (as directed to the human body's natural response to aspirin).

Id. at 1048-49 (emphasis in original).

Here, the asserted claims in the '722 patent are directed to a new and more efficient method for treating metal parts to change their physical properties, removing, reducing, or affecting (and in a few instances introducing) stresses or other characteristics. While the application of the Larson-Miller relationship may be an abstract idea in some contexts, that is not the case here. Independent Claims 1 and 11 disclose the use of the Larson-Miller relationship as an aspect of a method for "changing a physical property of a structure." '722 patent, col. 19, lines 43-44, col. 21, lines 47-48. Rather than attempting to claim the Larson-Miller relationship itself, the '722 patent draws upon the Larson-Miller relationship as a baseline or predicate for applying two energies concurrently above an activation energy of the material to be processed. PX 427 at 13. The novelty of the method is the application of the energies in a specific and

unconventional manner, in accord with the specific steps disclosed in the patent, to produce unexpected and desirable results. *See Enfish, LLC v. Microsoft Corp.*, 822 F.3d 1327, 1335-36 (Fed. Cir. 2016). For the three claims at issue, there is no attempt to patent the Larson-Miller relationship itself or to rest on that relationship as a basis for the unexpected results. *See Diehr*, 450 U.S. at 187 (noting that the patent at issue did not preempt a mathematical equation because it only relied upon "that equation in conjunction with all of the other steps in the[] claimed process").

The court described the novel application of the Larson-Miller relationship in its previous opinion regarding patent-eligible subject matter:

> Independent Claims 1 and 11 . . . do not merely restate straightforward applications of the known Larson-Miller relationship. The Larson-Miller relationship itself does not predict that *concurrent application of two energy processes* according to a *combined* first order rate relationship is a more efficient method of changing the physical properties of a structure.

Hitkansut III, 115 Fed. Cl. at 731 (emphasis in original). Dr. Wagoner elaborated upon the court's description, testifying:

> [The Larson-Miller relationship acts] as a scorekeeping device or way to characterize [the process], particularly since there's this acceleration which is time only, and then there's the efficiency which may be lowering temperature. The only way and the best way to do that is to have a combined parameter that has time and temperature in it and then are you doing the same effects at lower parameters or higher parameters. So, that's the way to do the efficiency at all one shot.

Tr. 2634:15-23 (Wagoner). Combining the two energy processes at above an activation energy of the material being treated is critical to the '722 patent because it ultimately allows the materials processing method to be conducted more efficiently, either through a reduction in energy or time. *See* '722 patent, col. 2, lines 33-38. For example, the application of heat and vibration concurrently achieves stress-relief in a material in less time when compared to the application of heat or vibration alone or seriatim, taken together. *See* '722 patent, col. 18, lines 22-26. Just as the patent in *CellzDirect* provided a better way of preserving hepatocytes, 827 F.3d at 1048-49, the claims in the '722 patent provide a more efficient way of treating materials. The asserted claims are therefore not directed to an abstract idea or other ineligible subject matter.[28]

[28]Earlier, as noted *supra*, the government had moved for summary judgment on its patent-ineligibility contentions. The court had granted that motion in part, *i.e.*, as "to independent Claims 7 and 14, and by extension to dependent Claim 8," *Hitkansut III*, 115 Fed. Cl. at 734, because these claims used the Larson-Miller relationship in a "straightforward manner" and "attribute[d] no special consequences to concurrent application" of energies, *id*. at 730.

Additionally, the claims sufficiently show an inventive step under step two of *Alice*. The government argues that there is no inventive step because the claims only consist of abstract ideas and "conventional processing steps," Def.'s Post-Trial Br. at 24-27, whereas Hitkansut counters that the additional elements of the asserted claims provide a new and more efficient means of materials processing. Pls.' Post-Trial Reply Br. at 14-15. In addressing step two of *Alice*, the government primarily relies upon two Supreme Court decisions, *Parker v. Flook*, 437 U.S. 584 (1978), and *Diehr*, 450 U.S. 175. *See* Def.'s Post-Trial Br. at 24-25.

In *Flook*, the patent at issue related to a method for updating "alarm limits" during catalytic conversion of hydrocarbons. 437 U.S. at 585-86. An alarm limit is a number that, when exceeded, can "signal the presence of an abnormal condition indicating either inefficiency or perhaps danger" during catalytic conversion processes. *Id.* at 485. The method included three steps: (1) measuring a process variable, such as temperature; (2) using an algorithm to determine an alarm limit value; and (3) adjusting the alarm limit accordingly. *Id.* The court acknowledged that "a process is not unpatentable simply because it contains a law of nature or a mathematical algorithm," *id.* at 590, but ultimately found the specific method at issue to be unpatentable because it failed to provide an inventive way of applying the mathematical algorithm. *Id.* at 594-95. The patent described a new method for calculating alarm limit values, but, without the algorithm, the only other steps involved monitoring chemical processes and updating alarm limits, both of which were already well-known. *Id.* In *Alice*, the Supreme Court described *Flook* as "stand[ing] for the proposition that the prohibition against patenting abstract ideas cannot be circumvented by attempting to limit the use of [the idea] to a particular technological environment." *Alice*, __ U.S. at __, 134 S. Ct. at 2358 (quoting *Bilski v. Kappos*, 561 U.S. 593, 610-11 (2010)) (internal quotation marks omitted).

Three years after *Flook*, in *Diehr*, the Supreme Court addressed a patent disclosing "a process for molding raw, uncured synthetic rubber into cured precision products." 450 U.S. at 177. Specifically, the process involved continuously measuring the temperature inside the mold and sending those measurements to a computer, which then repeatedly recalculated the cure time through the Arrhenius equation and sent a signal to the mold when the cure time was reached. *Id.* at 178-79. Prior to the invented process, the rubber industry had been unable to determine the precise temperature inside the mold, thus making it difficult to determine a specific mold time and to accurately cure rubber. *Id.* at 177-78. Although the Arrhenius equation was not itself patentable, the court held that the process was eligible for patent protection because the Arrhenius equation was used in combination with a number of specific steps related to curing rubber. *See id.* at 187. The patented process in the context of curing rubber incorporated "a more efficient solution of the [Arrhenius] equation." *Id.* at 188. The court distinguished the facts from *Flook*, stating that the claims in *Flook* did not "explain how the variables used in the formula were to be selected, nor did the application contain any disclosure relating to chemical processes at work or the means of setting off an alarm or adjusting the alarm unit." *Id.* at 192 n.14. Ultimately, in finding the process at issue to be patent eligible, the court in *Diehr* held that "when a claim containing a mathematical formula implements or applies that formula in a structure or process which, when considered as a whole, is performing a function which the patent laws were designed to protect (*e.g.*, transforming or reducing an article to a different state or thing), then the claim satisfies the requirements of [Section] 101." *Id.* at 192.

Here, the court finds the asserted claims in the '722 patent to be analogous to the claims in *Diehr* and distinguishable from the claims in *Flook*. The claims at issue refer to the Larson-Miller relationship and rely on first order rate relationships, but do so in a novel manner to engender more efficient results. As discussed *supra*, the concurrent application of multiple energies significantly reduces the time or temperature required to process materials, so long as the energies are applied above the activation energy of the material being treated, resulting in greater efficiency and cost savings. However, to achieve this efficiency, a "combined parameter that has time and temperature" is necessary. Tr. 2634:19-20 (Wagoner). This combined parameter is set based on previously obtained experimental data, which can be expressed mathematically as part of a first order rate relationship; in effect those data, representing a Larson-Miller relationship, act as a "scorekeeping device." Tr. 2634:15 (Wagoner). Just as the claims in *Diehr* used the Arrhenius equation in an inventive manner to cure rubber more efficiently, 450 U.S. at 187-88, the claims in the '722 patent rely on the Larson-Miller relationship in an inventive manner to process materials more efficiently. Both solve a technological problem in a way that can be expressed mathematically but is far more than setting out a mathematical formula and then applying it. *See Alice*, __ U.S. at __, 134 S. Ct. at 2358 (citing *Diehr*, 450 U.S. at 177, 178). When considered as a whole, the claims are not simply "attempting to limit the use of [the idea] to a particular technological environment," *id.*, but instead describe a novel method for transforming materials and "performing a function which the patent laws were designed to protect," *Diehr*, 450 U.S. at 192.

B. Obviousness

The government contends that a combination of prior art references renders the '722 patent obvious under 35 U.S.C. § 103. Def.'s Post-Trial Br. at 27-36. The government has the burden of proving obviousness by demonstrating "that a skilled artisan would have had reason to combine the teaching of the prior art references to achieve the claimed invention, and that the skilled artisan would have had a reasonable expectation of success from doing so." *PAR Pharm.*, 773 F.3d at 1193. In making an obviousness determination, the court is required to "step backward in time and into the shoes worn by [the skilled artisan] when the invention was unknown and just before it was made . . . [and] then determine whether the patent challenger has convincingly established . . . that the claimed invention as a whole would have been obvious at *that* time to *that* person." *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1566 (Fed. Cir. 1987) (alteration in original) (citations omitted); *see also Graham*, 383 U.S. at 3. The court does not consider hindsight. *Innogenetics, N.V. v. Abbott Labs.*, 512 F.3d 1363, 1374 n.3 (Fed. Cir. 2008) (recognizing that courts must "be careful not to allow hindsight reconstruction of references to reach the claimed invention without any explanation as to how or why the references would be combined to produce the claimed invention."). Additionally, before the court invalidates a patent due to obviousness, the court must consider secondary evidence of non-obviousness, such as "commercial success, long[-]felt but unsolved needs, [and] failure of others." *Graham*, 383 U.S. at 17-18.

1. Motivation to combine.

To demonstrate obviousness, the government cites eleven prior art references, separated into two categories. Def.'s Post-Trial Br. at 27-33. According to the government, the seven

references in the first category teach the application of two energies concurrently to a structure for the purpose of changing that structure's physical properties, *id.* at 28-31, and the four references in the second category rely on the Larson-Miller relationship to calculate processing times, *id.* at 32-33.

The first category of prior art references includes seven patents, consisting of: DX 69, the Brown '276 patent (United States Patent No. 3,999,276); DX 68, the Seror '152 patent (United States Patent No. 5,252,152); DX 67, the Unde '974 patent (United States Patent No. 6,223,974); DX 4, the Blood '589 patent (United States Patent No. 1,373,589); DX 5, the Otte '219 patent (United States Patent No. 1,978,219); DX 6, the Gaskins '658 patent (United States Patent No. 2,745,658); and DX 7, the Ettenreich '775 patent (United States Patent No. 2,848,775).

The Brown '276, Seror '152, and Unde '974 patents were all cited in the '722 patent. '722 patent, References Cited. The Brown '276 patent, which issued on December 28, 1976, is entitled "Method of Laying Railroad Rail" and claims a method for laying a railroad rail. It encompasses, among other things, "subjecting the rail to the combined effect of heat exchange and vibration" to produce "a stress-free rail." Brown '276 patent, col. 4, lines 32-45. The Seror '152 patent, which issued on October 12, 1993, is entitled "Method of Controlling Warpage in Workpiece by Selective Flame-Hardening and Vibrations." It describes "[a] method for stress-relieving a flame-hardened component by vibrating the workpiece as it is being flame-hardened, and then vibrating the workpiece after it has been flame-hardened. . . ." Seror '152 patent, Abstract. The Unde '974 patent, which issued on May 1, 2001, is entitled "Trailing Edge Stress Relief Process (TESR) For Welds." It discloses a process of applying "stress cycles during a welding process," Unde '974 patent, col. 5, lines 17-20, which reduces the "level of residual stress and discontinuities in the said weld," *id.*, col. 6, lines 14-15.

Dr. Druschitz identified four additional patents that were not considered in the prosecution history of the '722 patent. *See* Def.'s Post-Trial Br. at 30. The Blood '589 patent issued on April 5, 1921 and is entitled "Process of Seasoning Steel Articles." Claim 1 specifically provides that the process consists of:

> [P]lacing the articles in a liquid bath, slowly heating the bath with the articles to a relatively high temperature, permitting the bath with the articles to slowly cool to normal temperatures, and then alternately dipping the articles a large number of times in hot and cold baths at temperatures respectively above and below the normal temperature.

Blood '589 patent, col. 3, lines 33-41. The specification explains that "[u]nder some circumstances it may be desirable or preferable to vibrate the articles during some or all of the before mentioned heat treating steps. Vibration may be effected while the articles are in the initial high temperature bath or while in all of the baths." *Id.*, col. 3, lines 5-11. The Otte '219 patent issued on October 23, 1934 and is entitled "Method of Treating Metallic Materials." It describes:

> [A] method of improving the physical and/or magnetic properties of metallic materials that comprises heating the material to a temperature such that the

> material will take a predetermined amount of elongation, stressing the material to produce elongation, while so stressing the material, passing electric current through the same in the direction of elongation, and subjecting the material to the action of a magnetic field.

Otte '219 patent, col. 7, lines 24-33. The Gaskins '658 patent issued on May 15, 1956 and is entitled "Apparatus for Bringing Coil Springs to Test and Relieving Strains Therein While Under Load." It recites a "method of and apparatus for bringing [coil] springs to test while subjected to a constant test load." Gaskins '658 patent, col. 1, lines 16-18. The specification explains that "a certain amount of deflection" and "a load" are applied to the spring, then the heat is applied to the spring. *Id.*, col. 4, lines 54-58. The Ettenreich '775 patent issued on August 26, 1958 and is entitled "Method of Controlling the Properties of Metals and Metal Alloys by Irradiation with Vibrations." The invention is summarized as follows:

> This invention relates to a method of controlling the orders of magnitude of the properties of metals and metal alloys, for example steel, by subjecting them, in their solid or molten state, at temperatures corresponding to, or above the phase conversion state to the influence of vibrations of appropriate frequencies from an external source.

Ettenreich '775 patent, col. 1, lines 15-21.

The second category of prior art includes four references, consisting of the seminal article on the Larson-Miller relationship, Larson & Miller, *Rupture & Creep Stresses*, and three patents: DX 9, the Komatsu '417 patent (United States Patent No. 4,287,417); DX 10, the Starr '105 patent (European Patent No. 0 072 105 B1); and DX 11, the Clark '108 patent (United States Patent No. 5,050,108).

As noted earlier, Larson and Miller introduced a new conceptual approach in addressing the effects of time and temperature on the tempering of steels. They adapted rate functions to their findings about rupture and creep behavior with particular reference to turbine blade life. Larson & Miller, *Rupture & Creep Stresses*, at 765. The research resulted in the "descri[ption of] a time and temperature relationship for relieving creep stress and preventing catastrophic failure or rupture." *Hitkansut V*, 119 Fed. Cl. at 266 n.14; *see also* Larson & Miller, *Rupture & Creep Stresses*, at 770 (applying "the time-temperature relation expressed by the parameter T (C + log t)" to "rupture and creep data on a variety of alloys"); Tr. 1551:16-18 (Ludkta) (stating that the Larson-Miller parameter is used for "monitoring creep and predicting creep behavior"). Larson and Miller elaborated on the potential implications of their findings by stating:

> The implications of this concept are of great practical significance since a complete master curve may be constructed from short-time rupture data over a range of temperatures. Once this curve is obtained, long-time data within the limits of the parameter values covered may be calculated immediately. It also becomes possible to compare the complete rupture characteristics of various alloys on a single graph.

Larson & Miller, *Rupture & Creep Stresses*, at 766.

The cited patents that implicate the Larson-Miller relationship include the Komatsu '417 patent, which issued on September 1, 1981 and is entitled "Method of Determining the Deterioration of Heat-Resistant Ferritic Steel Parts." The method includes a step, among other steps, that makes use of the Larson-Miller relationship by:

> [C]alculating the length of time for the steel part to be used under practical operating conditions from the length of time for which the steel is applied under test accelerating conditions to achieve the value shown by said at least one crystallization factor by applying the Larson-Miller parameter $P = T (\log t + 20)$.

Komatsu '417 patent, col. 6, lines 12-18. The Starr '105 patent issued on April 8, 1987 and is entitled "Assessment of Life of Duct." The invention "relates to the assessment of the overall lifetime until failure of a pipe carrying a fluid such as a gas at elevated pressures and temperatures." Starr '105 patent, col. 1, lines 3-6. The specification explains that the Larson-Miller parameter is one of the steps used in "calculat[ing] the time to failure." *Id.*, col. 2, lines 18-41. The Clark '108 patent issued on September 17, 1991 and is entitled "Method for Extending the Useful Life of Boiler Tubes." The specification provides that "[t]he effects of time and temperature are combined into a single . . . Larson-Miller parameter," and "[a] projected creep condition is then derived for incremental time periods based on hoop stress and the Larson-Miller parameter." Clark '108 patent, col. 5, lines 54-56, and line 67 to col. 6, line 1.

Several aspects of the government's obviousness arguments are problematic. First, the government's prior art and obviousness analysis fails to address an essential element of each of the three asserted claims in the '722 patent: activation energy. Independent Claims 1 and 11 both provide that the concurrent application of two energies in total has to be above the activation energy for the material of the structure. '722 patent, col. 19, lines 63-65, col. 21, lines 53-56. In its claim construction order, the court construed "[a]ctivation energy for the material" to mean "the energy required for initiating a change in a property of the structure." *Hitkansut II*, 114 Fed. Cl. at 423.

Dr. Druschitz and Dr. Wagoner approach the "activation energy" limitation differently. In preparing his expert report regarding invalidity, Dr. Druschitz did not specifically address activation energy. *See* DX 3; Tr. 2051:5 to 2052:5 (Druschitz). In his testimony, Dr. Druschitz explained that under his interpretation of the court's construction, the term activation energy is "not significant" because "[a]ny process or any energy source that's causing something to happen" would satisfy the activation energy requirement. Tr. 2192:19-22, 2193:6-13 (Druschitz). Thus, according to Dr. Druschitz, activation energy is exceeded whenever a change in a physical property occurs, Tr. 2228:13 to 2229:5 (Druschitz), even if the change proceeds at a glacial pace, being in essence imperceptible over any reasonable time and requiring a great amount of time to produce results that can be discerned. In contrast, Dr. Wagoner testified that activation energy is a critical and unique feature of the '722 patent; exceeding the activation energy produces a more efficient method for changing the physical properties of a structure, either by reducing the time or temperature needed to process the material. *See* Tr. 2649:5-19, 2650:12-21 (Wagoner).

The court concurs that exceeding the activation energy is a critical element of the '722 patent. The Oak Ridge researchers themselves seem to agree. *See* PX 175 at 1 (stating that the TMP process could be "utilize[d] to minimize residual stress, accelerated phase transformation processes . . . and *enhance processes that have a threshold activation energy*") (emphasis added). In accord with the claim construction, exceeding the activation energy initiates a change in the property of the structure that is relatively quite rapid and proceeds with a significant saving in the time or the energy required, or both. That is the significant difference between Claims 1, 6, and 11 of the '722 patent and the prior art cited by the government in the first category of its references, *i.e.*, the Brown, Seror, Unde, Blood, Otte, Gaskins, and Ettenreich patents. As Dr. Wagoner explained, exceeding the activation energy through the concurrent application of multiple energies allowed Ms. Walker to achieve greater processing efficiency and ultimately produce unexpected results. Tr. 2649:5-13 (Wagoner). And in his deposition, Dr. Druschitz agreed that "combin[ing] a thermal and an oscillatory energy to exceed the activation energy . . . provid[es] an acceleration relative to the energy sources independently." Tr. 2653:21 to 2654:1 (Wagoner) (quoting Druschitz Dep.). Further, the specification of the '722 patent specifically contemplates this type of efficiency, providing that the disclosed method "significantly reduce[s] the time and/or energy required to change a physical property of interest, such as reducing remaining internal stress in manufactured parts or other structures, compared to previous techniques." '722 patent, col. 2, lines 35-37.

The government's second category of prior art focuses on the use of a Larson-Miller relationship in calculating processing times, useful life of parts, or time to failure, based on assessing creep life and creep failure. Tr. 2671:10-17 (Wagoner). But similarly to the first category, the references in the second category do not disclose a method that involves exceeding the activation energy of the subject material and enhancing or accelerating the changing of physical properties. Tr. 2671:7 to 2672:8 (Wagoner). A researcher studying the useful life of parts or lifetime before failure would not be addressing more efficient means of enhancing the properties of parts. Tr. 2641:5-10 (Wagoner).

Dr. Druschitz testified that only one reference, the Blood '589 patent, issued in 1921, discloses a purpose of processing materials "faster." Tr. 2282:24 to 2283:7 (Druschitz). Dr. Druschitz specifically explained that, in his opinion, the Blood '589 method teaches that "the combination of the elevated temperature and vibration or energy . . . relieve[s] the stresses [in materials] faster." Tr. 2077:20-22 (Druschitz). The method disclosed in the Blood '589 patent, however, is distinguishable from the method disclosed in the '722 patent at issue here. The Blood '589 patent relates to a method of dipping metals in hot and cold oil baths. Blood '589 patent, col. 3, lines 33-41. The method allows the metals to stabilize in a shorter time than in the circumstance of not applying *any* method to the metals. *Id.*, col. 3, lines 20-25; Tr. 2669:4-17 (Wagoner). Thus, while this method does contemplate faster processing, it only compares the time required to process the material using the disclosed method with the time required using a baseline approach of not applying any method. Additionally, Blood also provides that vibration may optionally be applied "during some or all of the . . . heat treating steps." Blood '589 patent, col. 3, lines 5-8. Even when vibration is applied, which is optional, there is no comparison between the application of one energy and two energies. *See* Tr. 2670:1-12 (Wagoner); Tr. 2283:8-11 (Druschitz). In contrast, the '722 patent instead explains that concurrent application

of multiple energies in excess of the activation energy produces greater efficiency when compared to the application of any one energy alone, or energies applied seriatim, such as standard heat treatment. *See* '722 patent, col. 16, lines 22-24. The Blood '589 patent and the other prior art do not address or teach, even when pieced together, element by element, the specific activation energy element of the '722 patent.

Second, the government has failed to demonstrate any motivation to combine the two groups of prior art. According to the government, "[g]iven that the second category of references disclose[s] methods of using the Larson-Miller relationship to calculate time values for processes altering physical properties, there is an inherent motivation to combine those references with the first category of references, which . . . describe the manner of performing the processes." Def.'s Post-Trial Br. at 36. To be accurate, however, the second category of references does not focus on the time for altering properties of parts in a beneficial way but rather addresses predicting deterioration and failure. To state the government's position in other terms, the first category of prior art primarily relates to stress relief through heat treatment and other energies, and the second primarily concerns use of the Larson-Miller relationship in establishing predicted time before part failure. The government fails to support its contention of a motivation to combine these categories. In preparing and presenting his obviousness analysis, Dr. Druschitz did not provide any combination of prior art that would render the asserted claims in the '722 patent obvious. Tr. 2053:10-15 (Druschitz); Tr. 2662:3-6, 2663:22-24 (Wagoner). The government describes an "inherent motivation" to combine, Def.'s Post-Trial Br. at 36, but the categories are in fact distinct, *see* Tr. 2645:11-22, 2665:1-13 (Wagoner). Most significantly, Dr. Druschitz testified that he had not seen the Larson-Miller relationship used to characterize the interaction between time and temperature for heat treatment to achieve a beneficial change in a metal part. Tr. 2256:4-18 (Druschitz). Dr. Wagoner testified that there was simply no motivation to combine these seemingly disparate categories before the '722 patent. *See* Tr. 2642:21 to 2643:4 (Wagoner). He explained that "the '722 process was the first to use Larson-Miller relationships to select times and temperatures in concurrently applying two energy sources to accelerate or enhance physical changes in certain materials." Tr. 2649:24 to 2650:3 (Wagoner).

2. Impermissible hindsight.

Further, Dr. Druschitz's characterization of prior art illustrates use of improper hindsight in selecting the prior art references. In searching for prior art, Dr. Druschitz testified that he began with the general field of the '722 patent, but then narrowed his inquiry by searching for specific keyword terms identified in the specification of the '722 patent, such as "Larson-Miller relationship, metals, residual stress, heat, [and] vibration." Tr. 2262:15 to 2264:20 (Druschitz). Additionally, in his deposition, Dr. Druschitz stated that he followed a "bit and piece" of each reference in assessing the obviousness of the '722 patent. Tr. 2664:1-9 (Wagoner). When presented with the concept of impermissible hindsight, Dr. Druschitz acknowledged that he was not aware of any prohibition on searching for all of the elements of a claim in order to combine them and find obviousness. Tr. 2269:6-11 (Druschitz). As a result, Dr. Druschitz used specific elements provided in the '722 patent to identify and combine references, even if he would not have thought to combine such references without the teachings of the '722 method. *See* Tr. 2646:3-7 (Wagoner). For example, Dr. Druschitz combined references related to heat treatment

with references related to the Larson-Miller relationship, despite the fact that he had not seen the Larson-Miller relationship used to characterize the interaction between time and temperature for heat treatment. Tr. 2256:4-18 (Druschitz); *see also* Tr. 2641:3-19; 2665:1 to 2667:8 (Wagoner).

In effect, Dr. Druschitz relied upon hindsight to perform a part-by-part analysis. Such an approach contravenes the language of 35 U.S.C. § 103, which provides that that a patent may not be obtained when the "differences between the subject matter sought to be patented and the prior art are such that the subject matter *as a whole* would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains." 35 U.S.C. § 103 (2006) (emphasis added). The Federal Circuit further elaborated on the "as a whole" requirement, stating:

> [I]n making the assessment of differences between the prior art and the claimed subject matter, [S]ection 103 specifically requires consideration of the claimed invention "as a whole." Inventions typically are new combinations of existing principles or features. The *"as a whole" instruction in title 35 prevents evaluation of the invention part by part. Without this important requirement, an obviousness assessment might successfully break an invention into its component parts, then find a prior art reference corresponding to each component.* This line of reasoning would import hindsight into the obviousness determination by using the invention as a roadmap to find its prior art components.

Princeton Biochemicals, Inc. v. Beckman Coulter, Inc., 411 F.3d 1332, 1337 (Fed. Cir. 2005) (internal citations omitted) (emphasis added). Dr. Druschitz undertook the mode of analysis that *Princeton Biochemicals* criticizes, and he would not otherwise have combined the references cited by the government. This approach is not consistent with the language of Section 103 or the teachings of the Federal Circuit.

3. Secondary considerations.

Secondary considerations "must always when present be considered en route to a determination of obviousness." *In re Cyclobenzaprine.*, 676 F.3d at 1075 (quoting *Stratoflex, Inc. v. Aeroquip Corp.*, 713 F.2d 1530, 1538 (Fed. Cir. 1983)). These considerations can include commercial success, industry praise, copying by others, the presence of a long-felt but unsolved need for the invention, and unexpected results. *See Apple Inc. v. Samsung Elecs. Co.*, 839 F.3d 1034, 1052 (Fed. Cir. 2016); *In re Huai-Hung Kao*, 639 F.3d 1057, 1067-68 (Fed. Cir. 2011). Although secondary considerations are not always dispositive, *In re Huai-Hung Kao*, 639 F.3d at 1067, they "may often be the most probative and cogent evidence in the record," *In re Cyclobenzaprine*, 676 F.3d at 1075 (quoting *Stratoflex*, 713 F.2d at 1538), and can guard against hindsight bias, *Graham*, 383 U.S. at 36.

"For objective [evidence of secondary considerations] to be accorded substantial weight, its proponent must establish a nexus between the evidence and the merits of the claimed invention." *Wyers v. Master Lock Co.*, 616 F.3d 1231, 1246 (Fed. Cir. 2010) (quoting *In re GPAC Inc.*, 57 F.3d 1573, 1580 (Fed. Cir. 1995)); *see also Demaco Corp. v. F. Von Langsdorff Licensing Ltd.*, 851 F.2d 1387, 1392 (Fed. Cir. 1988) ("The term 'nexus' is often used, in this

context, to designate a legally and factually sufficient connection between the proven success and the patented invention. . . ."). The plaintiff has the burden of presenting sufficient evidence to establish a *prima facie* nexus. *Demaco*, 851 F.2d at 1392 (citations omitted). "Once the patentee demonstrates a *prima facie* nexus, the burden of coming forward with evidence in rebuttal shifts to the challenger." *Crocs, Inc. v. International Trade Comm'n*, 598 F.3d 1294, 1311 (Fed. Cir. 2010) (citing *Demaco*, 851 F.2d at 1393).

Here, Hitkansut contends that the asserted claims in the '722 patent produced unexpected results, addressed long-felt but unmet needs, solved a problem that others had previously tried but failed to solve, experienced commercial success, received praise from others, and resulted in Oak Ridge copying the claimed method. Pls.' Post-Trial Reply Br. at 19-22. In contrast, the government asserts that a nexus has not been demonstrated between the claimed invention and any commercial success or laudatory comments, and that Oak Ridge did not copy the claimed method. Def.'s Post-Trial Br. at 34-35.

The court finds that Hitkansut has demonstrated a nexus between objective secondary evidence and the asserted claims in the '722 patent. The concurrent application of multiple energies, as claimed in the '722 patent, produces unexpected results by creating a more efficient method for treating materials. Specifically, the method changes the physical properties of a structure in less time or at a lower temperature, when compared to standard heat treatment. '722 patent, col. 2, lines 35-37. This efficiency can potentially create substantial energy savings in the materials processing industry, and thus addresses a long-felt but unsolved need. The objective evidence supports such a conclusion. For example, when Dr. Johnson of Oak Ridge observed Ms. Walker perform the method claimed in the '722 patent, he described it as "very successful . . . in demonstrating substantial energy savings." PX 136. And after learning of Ms. Walker's method in November 2003, Dr. Ludtka noted that the method had "potential for a lot of energy savings by being able to do things at significantly shorter times . . . and sometimes at lower temperatures." PX 180. Further, the '722 method achieves these savings through an unexpected use of the Larson-Miller relationship, which had not been previously used to address the interaction between time and temperature for heat treatment. Tr. 2256:4-18 (Druschitz); *see also* Tr. 2641:3-19, 2665:1 to 2667:8 (Wagoner).

Additionally, Hitkansut has demonstrated that Oak Ridge copied Ms. Walker's '722 method. Before November 2003, when Ms. Walker disclosed the '722 method to Dr. Ludtka and his Oak Ridge colleagues, Oak Ridge did not treat materials through the concurrent application of multiple energies. Tr. 2612:13 to 2613:9 (Wagoner). Instead, Oak Ridge's '513 patent, which was filed in 2002, discloses a method for achieving stress relief in a material "by placing the material in a magnetic field" while at "ambient temperatures." '513 patent, Abstract. In August 2003, Oak Ridge expanded upon its process by subjecting materials to elevated temperatures and then applying the magnetic field "under isothermal and continuous cooling conditions." PX 506 at ORL013-13082. Significantly, multiple energies were not applied concurrently. Oak Ridge did not elevate the temperatures of the materials or apply induction heating *while* applying the magnetic field. *See* Tr. 2612:6 to 2613:9 (Wagoner). Dr. Ludtka and Oak Ridge only began using an induction heating coil concurrently with a magnetic field at the end of 2003 and the beginning of 2004, after learning of the '722 method. *See, e.g.*, PX 175; '765 patent. This was a significant change in Oak Ridge's approach. *See* Tr. 2615:5 to 2616:14 (Wagoner). The

application of induction heating in conjunction with the magnetic field produced a force "so great" that it "surprised" the Oak Ridge researchers. Tr. 729:6-14, 730:6-10 (Kisner).

A nexus also exists between Oak Ridge's success with its TMP process and the asserted claims of the '722 patent. The government contends that Oak Ridge's success can be attributed solely to "the use of the superconducting magnet," Def.'s Post-Trial Br. at 35, but such contention refers not to the TMP process but rather to Oak Ridge's earlier efforts. Oak Ridge began studying metal processing in a magnetic field in approximately 1999. Tr. 1895:12-18 (Ludtka). Oak Ridge's success changed drastically, however, when it began using the concurrent application of multiple energies in 2004. In contrast to the single-energy magnetic field process in use before 2004, the concurrent application of the induction heater and magnetic field allowed Oak Ridge to substantially increase the efficiency by which it processed materials, thus creating significant energy savings. *See* Tr. 2613:13 to 2614:10, 2615:5 to 2616:14 (Wagoner). The potential efficiency and energy savings associated with the TMP process have been critical to Oak Ridge's success. *See* PX 31 at 7 ("The use of a coupled induction heat treatment with high magnetic field heat treatment makes possible not only improved performance alloys, but with faster processing times and lower processing energy, as well."); PX 45 at 3 (explaining in an award application that the TMP process is an "innovative technology [that] results in large process energy savings"); PX 175 at 1 (stating that the TMP process could be "utilize[d] to minimize residual stress, accelerate phase transformation processes . . . and enhance processes that have a threshold activation energy"). As a result of these savings, Oak Ridge has received industry praise from companies such as American Magnetics and Eaton Corporation, PX 45 at 17-19, and Dr. Ludkta has gained a significant increase in publications, Tr. 1598:21 to 1599:7 (Ludkta). It was therefore the concurrent application of multiple energies in Oak Ridge's infringing TMP process, rather than the magnetic field alone, that allowed Oak Ridge to succeed. Such a conclusion favors a finding of non-obviousness.

Thus, for the reasons stated, the asserted claims in the '722 patent are not invalid due to obviousness.

C. Enablement

As its third and final invalidity ground, the government contends that the asserted claims in the '722 patent are invalid because they fail the enablement requirement under 35 U.S.C. § 112 (2006). Def.'s Post-Trial Br. at 36-38.[29] A patent is invalid due to lack of enablement when

[29]The government did not raise an indefiniteness argument at trial or in its post-trial brief, but it was addressed in Dr. Druschitz's expert report submitted on behalf of the government. *See* DX 3 at 3.27. Under the pre-AIA version of Section 112, which applies here for the reasons discussed *supra* and is substantially similar to the AIA version of Section 112, the patent specification "shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention." 35 U.S.C. § 112, Paragraph 2 (2006). The Supreme Court has construed this provision "to require that a patent's claims, viewed in light of the specification and prosecution history, inform those skilled in the art about the scope of the invention with reasonable certainty." *Nautilus, Inc. v. Biosig Instruments, Inc.*, __ U.S. __, __, 134 S. Ct. 2120, 2129 (2014). The government must demonstrate

the government proves that "a person of ordinary skill in the art would not be able to practice the claimed invention without 'undue experimentation.'" *See Alcon Research*, 745 F.3d at 1188 (citations omitted). In *Wands*, the Federal Circuit outlined a set of factors "that a court may consider when determining whether the amount of that experimentation is either 'undue' or sufficiently routine such that an ordinarily skilled artisan would reasonably be expected to carry it out." *Id.* (citing *Wands*, 858 F.2d at 737). The factors include:

(1) the quantity of experimentation necessary,
(2) the amount of direction or guidance presented,
(3) the presence or absence of working examples,
(4) the nature of the invention,
(5) the state of the prior art,
(6) the relative skill of those in the art,
(7) the predictability or unpredictability of the art, and
(8) the breadth of the claims.

Wands, 858 F.2d at 737.

The enablement requirement serves the dual purpose of "ensuring adequate disclosure of the claimed invention and of preventing claims broader than the disclosed invention." *MagSil*

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indefiniteness by clear and convincing evidence. *Teva Pharm. USA, Inc. v. Sandoz, Inc.*, 789 F.3d 1335, 1345 (Fed. Cir. 2015).

The court finds that the asserted claims in the '722 patent are not indefinite. Independent Claims 1 and 11 disclose a "method of changing a physical property of a structure," '722 patent, col. 19, lines 43-44, col. 21, lines 47-48, and the court construed the term "structure" to mean "a physical object that has been constructed or manufactured and to which the claimed invention is applied." *Hitkansut II*, 114 Fed. Cl. at 416. Dr. Druschitz opined that the '722 patent is indefinite because it only teaches the application of the invented method to metals, whereas the court's construction of "structure" would apply the invented method to all materials, such as glasses or electronic materials. DX 3 at 3.27. However, "a patentee need not define his invention with mathematical precision in order to comply with the definiteness requirement." *Invitrogen Corp. v. Biocrest Mfg., L.P.*, 424 F.3d 1374, 1384 (Fed. Cir. 2005) (citation omitted). Rather, the terms must be read in the context of the invention. *See Sonix Tech. Co., Ltd. v. Publications Int'l, Ltd.*, __ F.3d __, __, No. 2016-1449, 2017 WL 56321, at *5 (Fed. Cir. Jan. 5, 2017). Similar to *Sonix Tech.*, where the court found that a "skilled artisan would understand, with reasonable certainty, what it means for an indicator in the claimed invention to be 'visually negligible,'" *id.*, Dr. Wagoner explained that "one of ordinary skill would expect only to apply [the invented method] to metals because of the underlying physical basis of the process as understood and disclosed by the inventor." PX 427 at 44. Dr. Druschitz's expert report provides support for this conclusion; Dr. Druschitz states that the '722 patent only teaches the application of the invented method to metals. *See* DX 3 at 3.27. As the Federal Circuit recently observed, "the level of ordinary skill in the art plays an important role in an indefiniteness analysis." *Tinnus Enters., LLC v. Telebrands Corp.*, __ F.3d __, __, No. 2016-1410, 2017 WL 344324, at *8 (Fed. Cir. Jan. 24, 2017). The court thus rejects any assertion that the '722 patent is invalid due to indefiniteness.

Corp., 687 F.3d at 1380-81 (citing *AK Steel Corp. v. Sollac & Ugine*, 344 F.3d 1234, 1244 (Fed. Cir. 2003)). The patent must be "precise enough" to provide the public with "clear notice of what is claimed" and "appris[e] the public of what is still open to them." *Nautilus*, __ U.S. at __, 134 S. Ct. at 2129 (internal quotation marks and citations omitted). Accordingly, to ensure adequate public knowledge, the scope of the enablement must be greater than or equal to the scope of the claims. *MagSil Corp.*, 687 F.3d at 1381 (citations omitted).

Here, the government argues that *Wands* factors one and two support a finding that the '722 patent fails the enablement requirement. Def.'s Post-Trial Br. at 37-38. Specifically, the government states that undue experimentation is needed to perform the disclosed method because the guidance provided in the '722 patent is "narrow and rife with errors." *Id.* at 37; *see also* DX 3 at 3.22-27. The court, however, already addressed and rejected this contention from the government. In its previous opinion regarding enablement, the court explained:

> In sum, while the '722 patent does contain representational errors and flaws in nomenclature, these errors are ultimately not significant because of the patent's incorporation of the Larson-Miller relationship, which is well understood and fundamental in the field of materials processing. A person of ordinary skill in the art would be able to correct the value of "C" for aluminum from 10 to 20, adjust the units of temperature "T" to degrees Rankine and the units of time "t" to hours, and apply a base-10 logarithm instead of a natural logarithm to the Larson-Miller calculation. . . . Because no undue experimentation would be necessary, the errors do not prevent the patent from enabling the protected process.

Hitkansut V, 119 Fed. Cl. at 265. The court found the errors in the '722 patent to be comparable to the errors in the patent at issue in *PPG Indus., Inc. v. Guardian Indus. Corp*., 75 F.3d 1558 (Fed. Cir. 1996). *See Hitkansut V*, 119 Fed. Cl. at 263-64. In *PPG*, the Federal Circuit stated that "the district court was justified in finding that undue experimentation would not be required," despite a calculation error in the patent. 75 F.3d at 1564. The Federal Circuit noted that "the question of undue experimentation is a matter of degree" and relied upon the district court's factual findings that the error in the patent was "harmless, inconsequential, and easily detectable by anyone who was skilled in the art of processing solar controlled glass." *Id.*

Similarly, the court finds the errors in the '722 patent to be inconsequential. In his expert report, Dr. Wagoner explained that despite "obvious typographical and minor mathematical errors," a person of ordinary skill could rely on the patent's "concrete example illustrating the use of the Larson-Miller parameters" to carry out the disclosed invention in approximately one hour, as Dr. Wagoner did. PX 427 at 37 (citing '722 patent, col. 13, line 50 to col. 16, line 31); *see also Hitkansut V*, 119 Fed. Cl. at 267 ("[A]ny missing information is provided by the incorporation of the Larson-Miller relationship."). Unlike previous decisions finding a lack of enablement because the patent required extensive experimentation, *see, e.g.*, *ALZA Corp. v. Andrx Pharm., LLC*, 603 F.3d 935, 941 (Fed. Cir. 2010), a person of ordinary skill in the art could either "readily correct[]" or "ignore[]" the errors in the '722 patent with "minimal analysis and without any experimentation." PX 427 at 37. Dr. Druschitz agreed that a person of ordinary skill in the art could account for the errors in the patent without undue experimentation and perform all necessary calculations within approximately one hour. Tr. 2241:16 to 2242:4

(Druschitz). The asserted claims in the '722 patent thus do not require undue experimentation, even given the errors contained in the specification.

The government also addresses *Wands* factor eight, asserting that the '722 patent "claims a breadth of subject matter well beyond its accompanying disclosure" because it does not provide "how the Larson-Miller relationship can be used to determine time and temperature in a thermal process" or how the "Larson-Miller relationship can be determined for the 'second energy.'" Def.'s Post-Trial Br. at 37. The government's argument, presented for the first time in its post-trial brief, fails to satisfy its burden regarding enablement. Dr. Druschitz did not address the government's specific "breadth of subject matter" argument in his expert report or trial testimony. *See* DX 3 at 3.22-27. Dr. Druschitz did not opine that he could not determine how to use the Larson-Miller relationship for the thermal or second energy. Instead, he testified that the calculations provided in the '722 patent could be performed in approximately one hour without undue experimentation. Tr. 2241:16 to 2242:4 (Druschitz). Dr. Wagoner further explained that one of ordinary skill in the art "would know how to follow the specification to calculate the Larson-Miller parameters, plot the results, and either solve for, or experimentally determine, the operational settings necessary to achieve the desired result . . . as directed by the '722 [p]atent." PX 427 at 42. The government has failed to present any evidence to the contrary.

Thus, the court rejects the government's contention that the asserted claims in the '722 patent are invalid due to lack of enablement.

III. REASONABLE AND ENTIRE COMPENSATION

Because the government infringed the asserted claims of the '722 patent, Hitkansut is entitled to recover "reasonable and entire compensation" for the government's compulsory non-exclusive patent license. *See* 28 U.S.C. § 1498(a).

A. Reasonable Royalty

The proper measure of monetary compensation starts with determining a reasonable royalty, *Standard Mfg.*, 42 Fed. Cl. at 758, that would have resulted from a hypothetical negotiation between the two parties at the time the infringement began, *Rite-Hite*, 56 F.3d at 1554.[30] A reasonable royalty is "calculated by determining a reasonable royalty rate and multiplying it by a reasonable compensation base." *Brunswick*, 36 Fed. Cl. at 209 (citation omitted). Such a royalty must be based on "sound economic and factual predicates." *Riles v. Shell Expl. & Prod. Co.*, 298 F.3d 1302, 1311 (Fed. Cir. 2002) (citations omitted).

[30]Both parties agree that the hypothetical negotiation would have taken place in February 2007, when the '722 patent was issued. Pls.' Post-Trial Br. at 48; Def.'s Post-Trial Br. at 47; *see also Applied Med. Res. Corp. v. United States Surgical Corp.*, 435 F.3d 1356, 1361 (Fed. Cir. 2006) ("We have held that a reasonable royalty determination for purposes of making a damages evaluation must relate to the time infringement occurred.").

1. Up-front fee.

The parties agree that a hypothetical negotiation between Oak Ridge and Hitkansut in February 2007 would have included a $200,000 up-front fee. Pls.' Post-Trial Br. at 57; Def.'s Post-Trial Br. at 39. Hitkansut's 2005 business plan supports such an arrangement. *See* PX 110 (Donna M. Walker, Acceledyne Corporation Business Plan 2005). In that plan, Hitkansut stated that it intended to "generate significant revenue both domestically and in other countries" by "licensing" the claimed method in the '722 patent. *Id.* at 3. As part of its marketing strategy, Hitkansut projected income from equipment sales, "an average up-front licensing fee of $200,000," and a 1.25% running royalty on sales generated by companies licensing the invented method. *Id.* at 8-9. Hitkansut anticipated more than 1,000 potential licenses. *Id.* at 9. Plaintiffs' damages expert, Joe Epps,[31] and the government's damages expert, Daniel McGavock,[32] both agreed that the hypothetical negotiation would have included a $200,000 up-front fee. Tr. 1328:19-23 (Epps); 2453:20-25 (McGavock).

2. Reasonable compensation base and royalty rate.

The parties disagree, however, on whether a reasonable compensation base exists beyond the $200,000 up-front fee. Hitkansut claims that the reasonable compensation base is approximately $45 million dollars, which is the amount that Oak Ridge has received in funding and has spent for TMP research projects. Pls.' Post-Trial Br. at 55-57. Hitkansut asserts that after applying a royalty rate of 8% to 10% to that compensation base, it would be entitled to between approximately $4.5 million and $5.6 million in damages. *Id*. at 58. The government responds that Hitkansut is only entitled to the fixed, $200,000 up-front fee and nothing more. Def.'s Post-Trial Br. at 38-54. According to the government, Hitkansut is not entitled to any additional compensation because Oak Ridge's infringing TMP process has not yet been commercialized. *Id*. at 39.

The court finds Hitkansut's position to be unsupported. Mr. Epps, Hitkansut's expert, testified that he had not seen a royalty rate applied to a funding amount received for research. Tr. 1335:19-21, 2596:12 to 2597:1 (Epps). Mr. McGavock agreed. Tr. 2463:2-7 (McGavock). Hitkansut instead attempts to justify its proposed compensation base by relying on *Madey v. Duke Univ.*, 307 F.3d 1351 (Fed. Cir. 2002), but such reliance is misplaced. In *Madey*, the Federal Circuit addressed the scope of "the experimental use defense" when a private party brought a patent infringement suit against Duke University. *Id.* at 1360-63. In granting summary judgment for Duke, the district court had considered that the experimental use defense

[31]Joe Epps has a Bachelor of Arts degree in business and accounting from California State University, and a master's degree in education from the University of Phoenix. PX 430 (Expert Report of Joe Epps, App. A). He was accepted by the court as an expert in forensic accounting. Tr. 1203:21-22.

[32]Daniel McGavock has a Bachelor of Science degree in accounting from Indiana University. DX 94 (Expert Report of Daniel M. McGavock) at 94.104. He was accepted by the court as an expert in accounting and in valuation and licensing of intellectual property. Tr. 2349:4-11.

protected a party from patent infringement liability when the alleged infringer's use was "solely for research, academic, or experimental purposes." *Id.* at 1361 (internal quotation marks and citation omitted). The Federal Circuit reversed the grant of summary judgment because, among other reasons, the district court had applied an overly broad definition of the defense. *Id.* at 1361-63. The Federal Circuit explained that "use in keeping with the legitimate business of the alleged infringer does not qualify for the experimental use defense." *Id.* In doing so, the Federal Circuit only addressed whether Duke could have infringed the petitioner's patent. The court then remanded the case for additional proceedings; it neither applied nor addressed damages. *See id.* at 1364. Although *Madey* relates to research in the context of patent infringement, it does not address whether research funding may be included in a royalty or compensation base and therefore does not lend support to Hitkansut's position.

The relevant *Georgia-Pacific* factors also support a finding of a fixed $200,000 fee with no further compensation. A reasonable royalty requires "sound economic and factual predicates," *Riles*, 298 F.3d at 1311, and Hitkansut's 2005 business plan provides that sound basis. Under *Georgia-Pacific* factor 4, the patent holder's established licensing and marketing practices, Hitkansut's business plan illustrates its intention to negotiate non-exclusive licenses of $200,000 with a running royalty for sales generated by the licensee. PX 110 at 8-9. Given the plan's proximity in time to the hypothetical negotiation, which would have occurred in February 2007, this evidence is persuasive. And because Oak Ridge has yet to commercialize its TMP process, Tr. 1636:17-25 (Ludtka), there are no sales for a running royalty to be applied. The TMP process is still in research and development, as Mr. Epps acknowledged. Tr. 1325:1-8 (Epps). Further, under *Georgia-Pacific* factors 3 and 12, the non-exclusive nature of the hypothetical license to Oak Ridge weighs in favor of a lower award. *See* DX 94 at 94.56 (noting that non-exclusive licenses are generally less expensive than exclusive licenses, as stated by Oak Ridge).

Georgia-Pacific factor 2, royalty rates for comparable technologies, also supports a $200,000 fixed fee. The government and Mr. McGavock cite three comparable license agreements: DX 125, a license between Purdue Research Foundation and Nano Dynamics, Inc.; DX 128, a license between the Penn State Research Foundation and Spheric Technologies, Inc.; and DX 139A, a license between Oak Ridge, acting through UT-Battelle, and Mesocoat Inc. *See* Def.'s Post-Trial Br. at 42-44; DX 94 at 94.57-61. Each of the three licenses included an up-front fee, ranging from $25,000 to $60,000, and a running royalty on sales. *See* DX 125 at 125.6 to 7; DX 128 at 128.5; DX 139A at 139A.12. In contrast, Mr. Epps found 196 licensing agreements related to metals and then selected the licenses in the highest royalty range, resulting in 25 licenses that, according to Mr. Epps, justified a high royalty for Hitkansut. *See* Tr. 1254:3 to 1255:7 (Epps). The court finds the licensing agreements relied upon by Mr. McGavock, not Mr. Epps, to be more relevant to a hypothetical licensing negotiation between Oak Ridge and Hitkansut. All three of Mr. McGavock's cited licenses were pre-commercial licenses, where the parties agreed to the licensing terms before the invention had been commercialized. *See* Tr. 2409:6-21, 2419:15 to 2420:24 (McGavock). The '722 method is similarly still in development, Tr. 2498:2-6 (McGavock), and had not yet been commercialized in 2007, as discussed *infra*, at n.33. Additionally, just as the '722 method has been praised for its potential benefits, the technologies involved in the three licenses cited by Mr. McGavock were highly regarded for their potential utility. *See* Tr. 2430:23 to 2431:7 (McGavock) (describing the technology in the

Purdue agreement, which related to nanostructured materials, as possessing "significant potential in industrial applications"); Tr. 2431:10-24 (McGavock) (describing the technology in the Penn State agreement, which related to microwave processing of materials, as having the potential to significantly reduce energy use); Tr. 2432:3-17 (McGavock) (describing the invention in the Oak Ridge agreement, which related to metal coating, as "revolutionary" with the potential to reduce costs and conserve energy). Due to the potential but not yet realized benefits, these licenses involved relatively small up-front fees and then running royalties on future sales. *See generally* DX 125; DX 128; DX 139A. Hitkansut's 2005 business model contemplates the same approach. PX 110 at 8-9. Given that Oak Ridge has yet to generate any sales from its TMP process, these comparable license agreements favor the government's proposed fixed fee of $200,000.

Hitkansut points to *Georgia-Pacific* factors 9, 10, and 11 in asserting that the invented method claimed in the '722 patent is innovative and highly praised, has great potential for utility due to its energy savings, and has brought Oak Ridge substantial praise. Pls.' Post-Trial Br. at 50-52. However, these attributes do not favor a higher royalty when viewed in a broader context. Despite the positive reception to Ms. Walker's '722 method, Hitkansut did not have significant commercial success at the time of the 2007 hypothetical negotiation. *See* Tr. 2498:14 to 2500:10 (McGavock) (explaining that Hitkansut's income related to the '722 method was only for testing, not full licensing agreements or commercialization).[33] The benefits promised by the invented method were only *potential* benefits. *See* Tr. 2498:2-6 (McGavock) (stating that the process has "huge potential" benefits, but "whether or not those benefits will be realized in a commercial setting at high volumes remains to be seen"). Ms. Walker did not have the resources to fully commercialize the process, and thus approached Oak Ridge. *See* Tr. 87:13-20, 88:6-8 (D. Walker); Tr. 414:10-14 (McCallister). Oak Ridge thereafter began developing its infringing TMP method and has received approximately $45 million dollars to do so, notwithstanding the risk that the possible benefits associated with the process might not be achieved. *See* 7 Donald S. Chisum, *Chisum on Patents* ("*Chisum*") § 20.07[2][h] (2016) ("The state of development and commercialization affects both the estimated amount of economic benefit to the prospective licensee and the level of uncertainty as to its future realization."). Thus, Oak Ridge's assumption of significant costs and risks has to be taken into account. *See* Tr. 2437:13-17, 2446:7-23 (McGavock); *see also Chisum* § 20.07[2][h] (explaining that a licensee would be less willing to agree to a high royalty rate at the time infringement began "if the product or process was paper technology that would require further investment in its development and commercialization").

[33]Hitkansut did receive approximately $1.25 million from General Motors for work related to the '722 method. Tr. 106:20 to 107:6 (D. Walker). However, Hitkansut received this revenue only for its "testing and evaluation" of the invented method. Tr. 370:1-6 (Test. of Bruce McCallister, former business development employee of Acceledyne); *see also* Tr. 85:24 to 86:16 (D. Walker) (stating that Hitkansut's work for General Motors involved "experiments" and "test protocol"); PX 471 (Letter from D. Walker to Dr. Paul N. Crepeau, General Motors Corporation (May 16, 2006)) at H0004802 (describing a "testing program" to "evaluate the effects of the Walker Process"). Hitkansut never reached a licensing agreement with General Motors. Tr. 109:15-25 (D. Walker). Other potential licensees only tested the process as well. *See, e.g.*, PX 466 (Letter from D. Walker to Dennis Jazkierny, Hayes Lemmerz (Dec. 9, 2003)) (proposing an examination and evaluation of the Walker Process through experimentation).

Accordingly, for the reasons stated, the court finds that a hypothetical 2007 licensing agreement between Hitkansut and Oak Ridge would have resulted in a $200,000 up-front fee. No further royalty is supportable because neither the '722 method nor Oak Ridge's TMP process have reached the commercial stage.

B. Delay Damages

Reasonable and entire compensation includes interest for delayed compensation of the royalty, which ensures "that the patent owner is placed in as good a position as he would have been in had the infringer entered into a reasonable royalty agreement" and "serves to make the patent owner whole." *General Motors Corp. v. Devex Corp.*, 461 U.S. 648, 655-56 (1983) (citations omitted). "Generally, the interest rate should be fixed as of the date of infringement, with interest then being awarded from that date to the date of judgment," or, more probably, the date of payment of the judgment. *Boeing*, 86 Fed. Cl. at 322 (citing *Nickson Indus., Inc. v. Rol Mfg. Co.*, 847 F.2d 795, 800 (Fed. Cir. 1988)).

With these principles as a guide, the court must determine "the rate of prejudgment interest and whether it should be compounded or uncompounded." *Boeing*, 86 Fed. Cl. at 322; *see also Datascope Corp. v. SMEC, Inc.*, 879 F.2d 820, 829 (Fed. Cir. 1989). Courts have selected, among other rates, the U.S. Treasury bill or note rate, the prime rate, the tax-overpayment rate based upon 26 U.S.C. § 6621, and the Contract Disputes Act rate based upon 41 U.S.C. § 611. *See Brunswick*, 36 Fed. Cl. at 219 n.4; *see also Chisum* § 20.03[4][a][v]. In applying the selected rate, courts often compound the delay-based interest because "no prudent, commercially reasonable investor would invest at simple interest." *Brunswick*, 36 Fed. Cl. at 219; *see also Dynamics Corp. of Am. v. United States*, 766 F.2d 518, 520 (Fed. Cir. 1985). Compounding is also consistent with "the way that post-judgment interest is calculated [by this court] under 28 U.S.C. § 1961(c)(3)." *Boeing*, 86 Fed. Cl. at 323 (citations omitted).

Here, both Mr. Epps and Mr. McGavock agreed that a Treasury note rate would be appropriate. Tr. 1296:2-6 (Epps); Tr. 2476:20-24 (McGavock). However, Mr. Epps applied a 10-year Treasury note rate, whereas Mr. McGavock applied a 1-year Treasury note rate. The court finds that a Treasury note rate sufficiently compensates Hitkansut because it reflects minimal risk, and that a 10-year Treasury note rate is warranted because it is consistent with the approximate length of time between the date of infringement and the date of judgment. Interest on a Treasury note is paid semi-annually, and it is therefore appropriate to compound the interest owed to Hitkansut semi-annually as well.

Accordingly, the court sets the interest rate for delay compensation at the 10-year Treasury note rate prevailing as of February 13, 2007, the date the '722 patent was issued. Interest on the $200,000 up-front fee to Hitkansut shall be calculated using the 10-year Treasury note rate for the period from February 13, 2007 until the date the judgment is actually paid, compounded semi-annually.

C. Future Damages

Additionally, Hitkansut requests that the court require the government to pay Hitkansut annually for Oak Ridge's continued use of the TMP process. Pls.' Post-Trial Br. at 58-59. The court, however, does not have jurisdiction to award relief for future infringements. *De Graffenried v. United States*, 228 Ct. Cl. 780, 784 (1981) ("[R]elief for future infringements is beyond the power of the court by declaratory judgment or otherwise."); *see also Motorola*, 729 F.2d at 768 n.3 ("[I]njunctive relief under 35 U.S.C. § 283 is not available to a patent owner in a [Section] 1498 action.") (citations omitted). Hitkansut's request for future damages is therefore denied.

CONCLUSION

For the reasons stated, the court finds that Claims 1, 6, and 11 of the '722 patent are valid and directly infringed by Oak Ridge's TMP method. The court awards Hitkansut $200,000 in damages as of February 13, 2007, the date the '722 patent was issued. Hitkansut is entitled to interest for delayed compensation at the 10-year Treasury note rate from February 13, 2007, compounded semi-annually, until the date the judgment is paid.

There being no just reason for delay, the court directs the clerk to enter final judgment pursuant to RCFC 54(b) respecting the reasonable and entire compensation for infringement. In due course, Hitkansut may apply for an award of reasonable costs and reasonable fees for expert witnesses and attorneys under 28 U.S.C. § 1498(a). Proceedings related to any such request for attorneys' fees and costs shall be deferred until after any appellate process has been concluded or, alternatively, after the time for taking an appeal has expired.

It is so **ORDERED**.

s/ Charles F. Lettow
Charles F. Lettow
Judge